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15.—Some Pelecypods from the Cretaceous Gingin Chalk, Western Australia, together with Descriptions of the Principal Chalk Exposures

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In this paper a number of pelecypods (lamellibranchs), mostly new, from the Gingin Chalk are described in detail and named, and descriptions are also given of the principal chalk exposures. The pelecypods include species of *Perna, Anomia, Spondylus, Plicatula, Ostrea, Gryphaea, Pycnodonta* and *Exogrya*. In the descriptions of the species occasional reference is made to specimens from the Toolonga Calcilutite of the Lower Murchison area.

Introduction

Pioneer geological and palaeontological work in the Gingin area was carried out by Mr. Ludwig Glauert, firstly as a member of the Geological Survey staff, and subsequently as Curator of the Western Australian Museum. Mr. Glauert was responsible for several papers and made the first geological map of the area.

With the exception of the Pectens (Feldtmann 1951) no new pelecypods from the Gingin Chalk have been described since the publication of Etheridge's paper on the Cretaceous fossils of the Gingin Chalk (Etheridge 1913). Glauert's list of Upper Cretaceous fossils (Glauert 1926) included, in addition to those described by Etheridge, species of *Pecten, Chlamys* and *Amussium*, but no descriptions were given.

Etheridge described and named *Pycnodonta ginginensis, Chlamys ellipticus* and *Mytilus piriformis*, and in addition to mentioning various species of *Inoceramus*, which he compared to species from Queensland and elsewhere, he also mentioned briefly and figured, but did not name, three species of oysters under the titles of "*Ostrea* sp. *a*," "*Ostrea* sp. *b*," and "*Ostrea* or *Pycnodonta* (Junr.)." These three last are described and named in this paper as well as species of *Perna, Anomia, Spondylus, Plicatula, Ostrea, Gryphaea, Pycnodonta* and *Exogyra*.

In connection with distribution of the various species, brief descriptions have been given of the more important exposures of the Gingin Chalk.

In 1944, a very large number of fossils was collected by the late Professor E. de C. Clarke and Dr. Curt Teichert from the Toolonga Calcilutite at various localities on the northern side of the lower Murchison River (Clarke and Teichert 1948), and more recently, a number of specimens was collected by Dr. B. F. Glenister and Mr. B. E. Balme from Thirindine Point in the same area. In the description of the Gingin species occasional reference is made to specimens from these collections.

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Location and General Geology

The small farming town of Gingin is situated 50 miles by rail north of Perth, on the Midland Company's line to Geraldton. It lies on both sides of the permanently flowing Gingin Brook, which, north-east of the town, flows in a south-south-westerly direction, but, after taking an abrupt U-shaped bend to the east immediately east-north-east of the town, changes to a west-south-westerly course through and west of the town. The town lies near the western edge of remnants of a former plateau of Mesozoic rocks situated between the main north-striking Darling Fault, which separates it from the Precambrian meta-sediments to the east, rather more than 8 miles east of Gingin railway station, and a second fault striking about north-north-west, which apparently diverges from the Darling Fault a little south of Bullsbrook some 24 miles to the south-south-east. Shot-holes put down for the West Australian Petroleum Proprietary Co. Ltd., and examined by Mr. S. Warne (unpublished data) indicate that this second fault is approximately $1\frac{3}{4}$ miles west of Poison Hill, 4 miles north-north-west of Gingin railway station. In the immediate neighbourhood of Gingin, the plateau has been largely eroded by Gingin Brook and its tributaries, but from about a mile north-west of Poison Hill, northward, the western escarpment of the plateau is remarkably regular with a general trend of N.24°W., and this is very probably the approximate strike of the fault. This would put it about a mile west of the escarpment north of Poison Hill and approximately the same distance west-south-west of One Tree Hill and Gingin railway station. From 3 miles south of Gingin it is probably very close to the Midland railway line. The higher points on the plateau are now mostly between 700 feet and 780 feet above sea-level. West of the fault, the surface is much lower, mostly between 180 feet and 270 feet above sea-level, and the rocks are largely obscured by the sands of the coastal plain.

The Mesozoic succession, and the approximate thicknesses of the formations are as follows:—

Upper Cretaceous.—

Poison Hill Greensand—possibly 170 feet to 250 feet.

Gingin Chalk—nil to 70 feet.

Molecap Greensand—20 feet or less to more than 90 feet?

Unconformity.

Lower Cretaceous.—

Strathalbyn Beds—between 170 feet and 180 feet exposed in the Gingin area.

Strathalbyn Beds

The Strathalbyn Beds were formerly regarded as Upper Jurassic from the identification by Walkom (1944) of plant remains found in ferruginous sandstone near the top of the formation in Cheriton Gully, 22 chains east of McIntyre Gully. In addition to the species identified by Walkom, specimens of an *Otozamites*, associated with *Taeniopteris*, were found more recently at approximately the same horizon about 15 chains west of McIntyre Gully. The beds are now regarded by Mr. B. E. Balme (personal communication) as of Lower Cretaceous (Aptian) age, from material obtained from some of the shot-holes and from shallow holes below the floor of Molecap quarry.

The longest exposure of the beds is in McIntyre Gully, in the Strathalbyn property, where they consist mainly of fine and coarse ferruginous sandstones, party bleached and finely micaceous in places. In McIntyre Gully the uppermost beds are pale grey to pale brownish yellow, and appear to be more shaly in character. At the northernmost exposure in the gully, the Strathalbyn Beds are separated from the overlying Molecap Greensand by a pale yellowish lateritic layer, four inches thick, containing fragments of fossil wood. This lateritic layer, found elsewhere at the top of the beds in places, doubtless represents a former land surface, much eroded in places before the Upper Cretaceous marine sediments were laid down. Less weathered examples of the beds occur in two small watercourses near the foot of the southern slope of Moorgup Hill, about $1\frac{1}{4}$ miles south-east of the railway station. Here the beds, immediately below their contact with the Molecap Greensand, consist of bands, from 4 inches to 8 inches thick, of fine-grained, pale grey arenaceous shales containing a few coarse quartz grains and with inch-wide flakes of muscovite on bedding planes, alternating with bands of coarser red sandy grit. Small angular fragments of black carbonaceous material were noticed in one 6-inch band of more sandy shale. The beds here have a very slight easterly dip.

The beds also occupy a low ridge partly enclosed by the U-shaped bend of Gingin Brook north-east of the town. Here, pale grey, fine-grained, apparently argillaceous sandstone with much fine white mica is exposed in a few shallow potholes on the backbone of the ridge. In Molecap quarry, auger-holes exposed yellowish brown clay, very similar in appearance to the top layers of the Strathalbyn Beds in McIntyre Gully, below the greensand at 7 feet 8 inches below the main floor of the quarry. Water was encountered at the junction of the two formations.

Molecap Greensand

The Molecap Greensand (Feldtmann 1934) a glauconitic sandstone, is a fairly fine-grained, dark greyish green rock, usually of homogeneous appearance and without visible bedding. At the type locality, a thickness of about 28 feet is exposed in the quarry, and auger-holes show it to have a total thickness here of 36 feet. The last 2 feet 6 inches encountered in the auger-holes above the Strathalbyn Beds was oxidised to a ferruginous brown sand. A thin band with phosphatic nodules was said to have been found at the base, in an auger-hole put down for the company quarrying the greensand, the glauconite being used as a water-softener. At the top of the greensand, a band, from about 3 inches to 30 inches thick, of dark reddish brown ferruginous material, with phosphatic nodules up to about 8 inches in diameter as well as rare bone fragments and other fossils, separates it from the overlying chalk.

At One Tree Hill, nearly $1\frac{3}{4}$ miles north-north-west of Molecap, the thickness of greensand appears to be about the same. The phosphatic band is absent here. At McIntyre Gully, the observed thickness between two points was only 21 feet 7 inches and as the junction between the Strathalbyn Beds and the greensand showed a slight southerly dip the thickness is probably even less farther north, and in a shot-hole three-quarters of a mile north-east it was only 20 feet. It appears, however, to thicken fairly rapidly to the west. At one point in McIntyre Gully, the lowest foot of the greensand has been altered to a yellowish brown colour and contains small irregular phosphatic nodules. The uppermost five feet of the greensand in the gully becomes gradually paler in colour as it approaches the base of the chalk and appears to pass into it without any defined break.

Although the Molecap Greensand is usually of even texture and fine grains, occasional coarser facies occur. In small watercourse rather more than half a mile north-west of One Tree Hill, greensand with fairly numerous grains of quartz and orthoclase up to about 3 mm in length was seen.

Not many fossils are found in the Molecap Greensand. The writer found two small saurian limb bones, one about 7 inches long, as well as smaller fragments, in McIntyre Gully at about five feet below the base of the chalk and specimens of *Spirulaea gregaria*, small belemnites, and two species of Chlamys were found by Dr. R. W. Fairbridge at about 10 feet below the base of the chalk (Feldtmann 1951, p. 24). A few rare bones occur near the top of the formation at Molecap and bone fragments were also seen, near the top, in a watercourse immediately north of the Mooliabeenie road, a short distance east of Musk's Chalk. The writer also found specimens of fossil wood in the greensand in the more westerly small gully near the base of the southern slope of Moorgup

GEOLOGICAL SKETCH MAP OF GINGIN

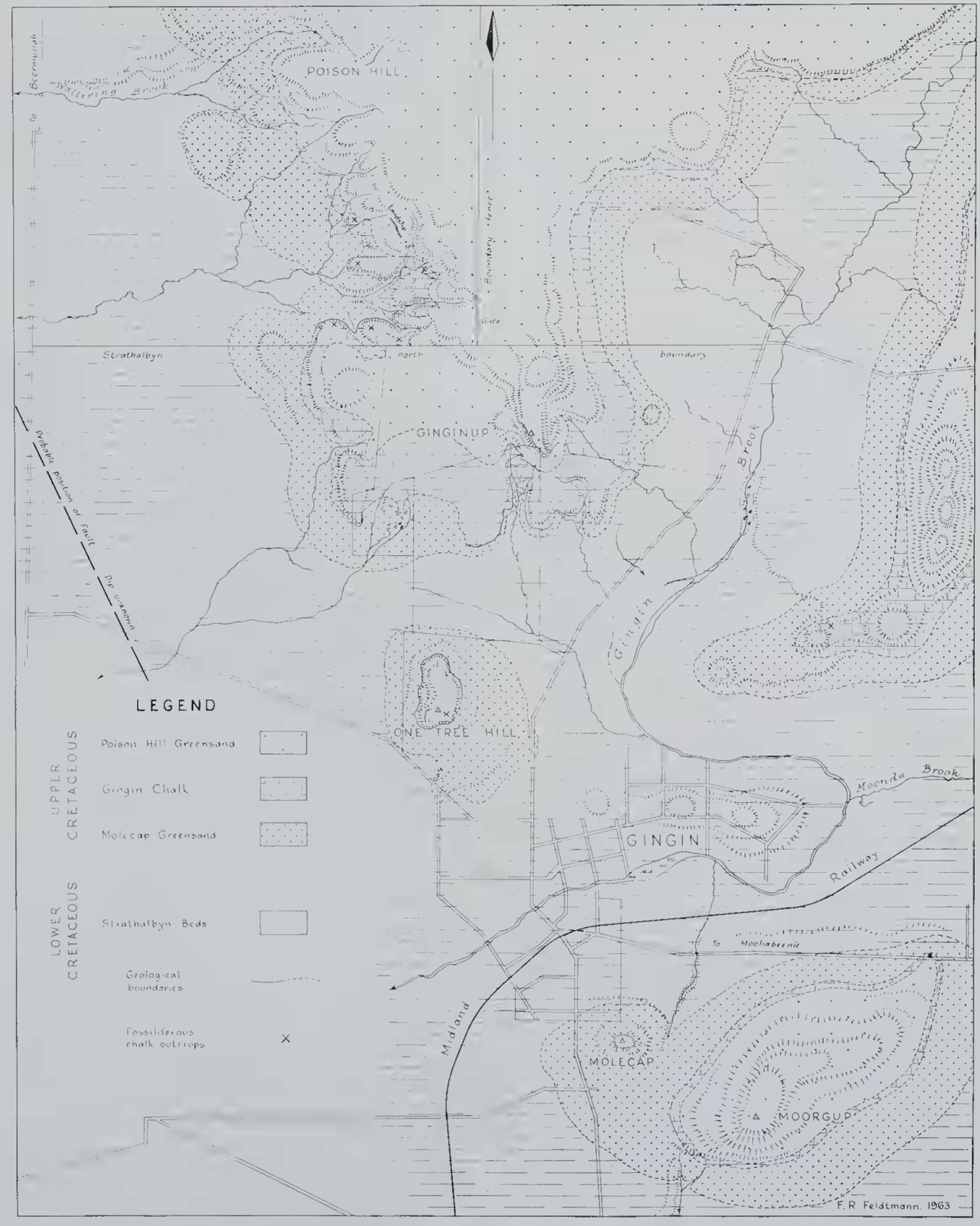

Fig. 1.

At Poison Hill, where the chalk is absent, the Molecap Greensand appears to pass into the Poison Hill Greensand without a break.

The heavy mineral content of the Molecap Greensand, mainly magnetite, was estimated at about one per cent. by Carroll (1941).

Gingin Chalk

The Gingin Chalk forms a discontinuous layer of varying thickness between the Molecap and the Poison Hill Greensands. It consists mainly of carbonate of lime with varying proportions of grains of glauconite, quartz and some orthoclase. The heavy mineral content was described in detail by Carroll (1939) who estimated it at 0.07 per cent. Detailed descriptions of the principal chalk exposures are given on subsequent pages.

Poison Hill Greensand

The best exposures of the Poison Hill Greensand are at the type locality and immediate vicinity and at a prominent landslip, about ¾-mile south-south-east. Good exposures of the base of the formation, above the chalk, are visible in two small gullies south-east of the landslip and about half-way between Poison Hill and Ginginup, and also at Southern's Chalk*, about ¾-mile north-west of Ginginup. The slightly weathered rock was exposed on the southern slope of Moorgup, about a mile south-east of the railway station, by a landslip, about 40 years ago, but has since been partly covered up by further slipping. Like the Molecap Greensand, the Poison Hill Greensand is a fairly fine-grained dark greenish rock consisting mainly of glauconite and quartz with some orthoclase; a little clay is present in places. According to Carroll (1941, p. 85), the heavy mineral content is very small, less than in the Molecap Greensand. The unweathered rock is usually of more or less homogeneous appearance, but an exposure of much-weathered oxidised rock on the south-eastern face of the Ginginup escarpment shows it too consists of beds, three or four inches thick, of both fine and coarse sandstones, some even approaching a grit.

Small pea-shaped nodules of the rare mineral gearksutite ($CaF_2AlFOH(F,OH)H_2O$) were found by Simpson (1920, p. 27) in a rather clayey bed, about 12 inches thick, with abundant glauconite and small phosphatic nodules. The bed was exposed in a small shaft on the north-eastern slope of Moorgup, about 2 chains south of the Mooliabeenie road and nearly opposite Musk's Chalk. Simpson also mentioned other somewhat clayey bands carrying small phosphatic nodules farther up the slope.

So far as I know the only organic remains found in the Poison Hill Greensand are coprolites, which, according to Simpson (1937, p. 38, Fig. 3) are abundant in certain bands, associated with bands carrying the phosphatic mineral dufrenite ($Fe_2(OH)_3PO_4$), at the landslip south-south-east of Poison Hill.

On much of the high ground between Ginginup and Poison Hill, the greensand is capped by dense ferruginous laterite up to about two feet thick in places.

No Upper Cretaceous rocks have been found south of Lennard's Brook, about two miles south-south-east of the railway station. Eclipse Hill, south of the brook and about 3¼ miles south-east of the station, presents a very different appearance from Moorgup, north of the brook, on the southern face of which the Upper Cretaceous succession shows up very noticeably, whereas on Eclipse Hill, which is slightly higher, there are no rock outcrops and the hill is entirely covered by white or grey sand very different from the dark reddish brown sand derived from the greensands. It is probable that the straight easterly portion of Lennard's Brook follows a line of transverse faulting.

Pleistocene Drift

An unexpected discovery early in May, 1949, was that of a fairly extensive deposit of Pleistocene drift in the upper portion of McIntyre Gully. The best exposure is on the west side of the gully, 120 feet south of where joined by the second small eastern tributary, and 590 feet south of the head of the gully. Here, portion of a lower jawbone with four large teeth, identified by Mr. Glauert of the Western Australian Museum as belonging to the extinct giant marsupial *Nototherium mitchelli,* was found lying on the floor of the drift by a student, D. A. Woodman. Other bone fragments were also found lying on the drift-floor, which is 2 feet 6 inches above the present floor of the gully. The base of the drift, which here is lying on greensand, is marked by an inch-thick layer of red ferruginous material. Above it, the drift consists of compacted greensand containing nodules and some larger boulders of chalk to 1 foot 9 inches above the base, followed by a 3-inch layer of grit, then soil to about 3 feet above the base, followed by soil with layers of grit to about 6 feet 6 inches above the base. The top of the drift is about 16 feet above the present stream-bed. On the west bank of the gully, the drift appears to tail out a few feet south of the exposure, but it extends northward for about 160 feet. Further search, a fortnight after the first discovery, revealed a second exposure of the drift about 135 feet north of the first and a few feet north of the junction with the small eastern tributary. Here, the drift is resting on the chalk and consists of material derived therefrom. Bones found resting on the floor of the drift at this exposure included a limb bone, scapula, vertebra, and two terminal toe-bones. The top of the drift here is also about 16 feet above the present stream bed. The post-Pleistocene portion of the gully is considerably narrower than that of Pleistocene times, indicating rejuvenation. The drift appears to be present in places on the eastern side of the gully, but its boundaries are ill-defined and there are no exposures.

The Chalk Exposures

In the Gingin area the Gingin Chalk forms a more or less tabular layer of varying thickness deposited when and where conditions, such as depth of water, were favourable between the

* Note that the terms Southern's Chalk, Musk's Chalk, Hosking's Chalk and North Chalk are not formation names. They refer to exposures of the Gingin Chalk, and may be located on the map (Fig. 1) from the information in the text.

lower or Molecap Greensand and the upper or Poison Hill Greensand. Where fully exposed the chalk grades into the greensands below and above, the boundaries between them being somewhat indefinite and difficult to determine with accuracy. At most of the exposures however, the section is incomplete, either the lowest or uppermost layers of the chalk being absent and the junctions between the chalk and the greensand abrupt.

The northern limit of the Gingin Chalk is about 3½ miles north-north-west of the Gingin railway station and half a mile south of Poison Hill, the most prominent point on the escarpment. At Poison Hill, where it is absent, the Molecap Greensand appears to pass without a break into the Poison Hill Greensand. The combined formations probably range from Coniacian to Campanian or even Maestrichtian in age (McWhae *et al.* 1958, pp. 116, 117, Table 7), the Gingin Chalk itself being Santonian. The Gingin Chalk reaches its maximum thickness of about 70 feet in the vicinity of McIntyre Gully, a little more than two miles north of the railway station. To the south, it appears to be thinning again at the scuthernmost exposure on the southern slope of Moorgup Hill, not quite 1½ miles south-east of the station, and near the southern limit of the Upper Cretaceous rocks.

The chalk consists mainly of varying proportions of carbonate of lime, quartz grains and glauconite, and according to Carroll (1939, p. 228) grains of orthoclase are also present. Clay is present at some horizons, particularly at McIntyre Gully. In a typical specimen of purer chalk from Molecap quarry, Carroll estimated the carbonate of lime at 87.3% and the glauconite at about 9%; the heavy mineral content was estimated at about 0.07%: this last (Carroll 1939, pp. 228-230) consisted mainly of minerals of metamorphic origin, without doubt derived from the Chittering Valley belt of metasediments and gneisses east of the Darling Fault.

From south to north, the principal exposures of the Gingin Chalk are at Molecap Hill, Musk's Chalk, One Tree Hill, McIntyre Gully, Southern's Chalk, the Springs Gullies, Hosking's Chalk, and North Chalk (refer Fig. 1). Of these, the most important is McIntyre Gully, just over two miles north of the railway station, as only there, is the formation complete, either the lower of upper layers or both, being missing from the other exposures. A dctailed survey of the gully and its tributaries by the writer in 1939, showed the total thickness of the formation to be approximately 67 feet 4 inches, but the position of the base of the Gingin Chalk, at its junction with the lower or Molecap Greensand, is determinable only with difficulty under the most favourable conditions, and is more or less arbitrary, as the last five feet of the greensand bccomes progressively paler and less highly glauconitic, with small lenticles of chalk, and appears to pass into the formation without any defined break. As determined by the writer, the base of the Gingin Chalk is situated near the base of the second small eastern tributary, at its junction with the main gully at about 470 feet south of the head of the gully. Here it is approximately 2 feet 6 inches above the stream bed of the main gully. It is also exposed on a cliff face about 200 feet farther south, where the gradual change from a fairly dark grey, mottled, highly glauconitic rock, with a few lenticles of chalk and a few fragments of small pelecypods, to a paler rock with less glauconite and more numerous lenticles of chalk can be seen. Above the base, the Gingin Chalk may be described as follows:—

0 ft-4 ft 2 in.: mottled grey glauconitic chalk, probably somewhat clayey.

4 ft 2 in.-about 10 ft; more even-textured pale grey chalk.

10 ft-19 ft 3 in.: fine-grained pale yellowish to white, somewhat sandy, fairly typical chalk, slightly glauconitic.

19 ft 3 in.-20 ft 3 in.: very clayey fine-grained grey chalk.

20 ft 3 in.-23 ft: fairly typical, nearly white chalk.

23 ft-about 33 ft: mottled grey, probably clayey, marly chalk with more glauconite.

33 ft-about 42 ft: less distinctly mottled, grey, marly, somewhat glauconitic chalk.

42 ft-48 ft: grey glauconitic chalk without mottling.

48 ft-62 ft: increasingly glauconitic and darker greenish grey rock.

62 ft-67 ft 4 in.: rock practically indistinguishable from greensand in appearance.

The last two sections were exposed in the first small eastern tributary, which enters the main gully at about 307 feet south of the head.

The position of the top of the formation was determined on the noticeable change of soil and a marked change of slope, rather than on the appearance of the rock itself. A definite outcrop of the Poison Hill Greensand was exposed a few inches above the assumed top of the Gingin Chalk.

Regarding the fossil distribution, plates of *Uintacrinus* are fairly common between the base of the chalk and 13 ft 3 ins. above, particularly between 4 feet and 10 feet. At approximately 13 ft 3 in. *Uintacrinus* gives place to *Marsupites*. An overlap of the two stalkless crinoids has not been established in this locality, but at Molecap there is a definite overlap of about 8 inches. Between 8 ft 9 ins. and 10 feet in the main gully, a layer of the large quadrate *Inoceramus* compared by Etheridge (1913, p. 21) to *I. maximus* Lumholtz forms the lip of a small waterfall. This species appears to be confined to the *Uintacrinus* zone, as do the small coral *Coelosmilia ginginensis*, *Chlamys subtilis*, and the large pachydiscoid ammonite compared to the English *Parapuzosia* by Spath (1926, p. 54). *Tubulostium pyramidale* is commonest in this zone, but its vertical range extends to 17 feet or 18 feet above the base of the formation. Some of the commoner fossils, such as *Cidaris* spines, *Spirulaea (Tubulostium?) gregaria*, the brachiopods *Bouchardiella cretacea*, *Kingena mesembrinus*, and *Inopinatarcula acanthodes*, *Plicatula glauerti* and the oysters *Ostrea etheridgei*, *Pycnodonta ginginensis* and *Exogyra variabilis* have a much wider range, extending from the base to at least 44 feet or 45 feet above.

The *Marsupites* zone extends from 13 ft 3 ins. to 20 ft 3 ins. above the base. A few plates of the smooth form are found in the lowest portion of this zone, plates with the typical *M. testudinarius* sculpture being more numerous in the middle and upper portions. This zone is richest in fossils, characteristic forms being *Peronella globosa*, various brachiopods including, in addition to the commoner forms, species of *Terebratulina* and *Magnithyris*. Pectens, including *Syncyclonema subreticulata* and *Chlamys ginginensis* occur in the upper half of this zone, where also *Pycnodonta ginginensis* attains its greatest size, and plates of the cirripedes *Calantica ginginensis* and *Scalpellum glauerti* are not uncommon. The characteristic species of *Inoceramus* is a large ovate nearly smooth form, of which a nearly perfect specimen 27 inches in length was found by Dr. Curt Teichert between 17 ft 9 ins. and 18 ft 3 ins. above the base. Equally large specimens seem to have been particularly common at this horizon, although, judging by the thickness of the fragments found, the species evidently extended to about 35 feet above the base.

The band of grey clayey chalk between 19 ft 3 ins. and 20 ft 3 ins. is particularly rich in small smooth or faintly plicate rhynchonellids, somewhat resembling *"Rhynchonella" limbata* Sow. and probably representing more than one species. A new *Terebratulina*, as well as other brachiopods, are fairly common at and just below this horizon. A few small sponges, including conical forms, a rare squat, mushroom-shaped species, and one resembling *Peronella globosa* Eth. fil., but more elongate in shape, were found immediately above the clayey band. A narrow zone between 21 feet and 23 feet above the base is characterized by numerous specimens of *Ostrea philbeyi*, which is almost wholly restricted to this zone, although a single small right valve was found close to the top of the *Marsupites* zone. The species is particularly common in the second small eastern tributary. Specimens of a small finely ribbed rhynchonellid resembling some species of *Burmirhynchia* occur between 23 feet and 28 feet above the base and a few unusually large specimens of *Inopinatarcula* were found at about 28 feet. From about 29 feet to 44 feet the fossils are mostly restricted to the commoner forms, but specimens of a small *Terebratulina* were found between 32 feet and 39 feet, and a few of the small pecten *Pseudamussium candidus* were found in the second eastern tributary at about 35 feet above the base. No macrofossils have, so far as I know, been found between about 45 feet and 64 feet above the base. Between 64 feet and the top of the formation, however, fragments of a thin-shelled *Inoceramus*, probably of a species different from those occurring at lower horizons, were found.

At Molecap Hill, half a mile south-east of the railway station, the thickness of chalk and chalk soil is 14 feet 7 ins., about 11 feet of chalk being exposed in the quarry, but of this only the lower 9 feet contain recognizable fossils. Distribution of the fossils in general, and of the two stalkless crinoids in particular, indicates that, compared with McIntyre Gully, approximately the lowest 11 feet of chalk is missing, probably due to contemporaneous erosion, and as the 28 ft 6 ins. of Molecap Greensand exposed in the quarry—bores show the total thickness of greensand to be 36 feet—is homogenous in appearance, possibly as compared with McIntyre Gully, a small thickness is missing from the top of this formation also. The junction between the chalk and the greensand is abrupt and is marked by a ferruginous band from 3 inches to 30 inches thick, containing numerous phosphatic nodules. Fossils found in this band include many small shark teeth, portion of the lower jawbone, as well as a few small teeth, probably of a small *Mosasaurus*, several centra of *Ichthyosaur* vertebrae, a vertebra of one of the Salmonidae, and fragments of fossil wood containing numerous *Teredo* casts.

The Gingin Chalk at Molecap Hill has proved rich in all the commoner fossils and single specimens of species not found elsewhere have been found here. These include a single valve of *Crania* sp., a small rhynchonellid unlike those of McIntyre Gully, and a small conical coral.

The lowest foot of the formation is more highly glauconitic and of slightly coarser texture than that above and contains numerous coarse quartz grains and a few small phosphatic nodules. The remainder consists of typical white or pale yellowish rather sandy rock from which most of the glauconite has disappeared. There is a definite overlap of 8 or 9 inches of the two stalkless crinoids, *Uintacrinus* extending from the base of the formation to at least 3 ft 2 ins. above, where a smooth plate of *Marsupites* was found at approximately 2 ft 6 in. The two forms of *Marsupites* also overlap, the smooth form extending to about 5 feet above the base, whereas the sculptured forms range from about 4 feet to the top of the less weathered portion of the exposure, some large plates occurring between 7 feet and 8 feet. Of the rarer fossils, the large pachydiscoid ammonite appears to be confined to the lowest foot of the formation, whereas the other ammonites *Eubaculites* and *Glyptoxoceas* have been found in the *Marsupites* zone. *Perna* and *Spondylus* appear to be confined to the *Uintacrinus* zone and the lower portion of the *Marsupites*, as do also *Mytilus piriformis* and a *Dentalium*. Of the pectens, *Chlamys subtilis* is confined to the *Uintacrinus* zone, and *C. ginginensis* to the lower portion of the *Marsupites* zone. *Syncyclonema* ranges from about 3 feet to 8 feet above the base. Strangely enough, whereas in McIntyre Gully *Pseudamussium candidus* was found only at about 15 feet above the top of the *Marsupites* zone, at Molecap it is common between 3 feet and 6 feet above the base of the formation. Rare fragments of a *Holaster*-like echinoid occur in both zones. Although fragments of *Inoceramus* are very common, some occurring in thin layers, recognizable specimens are rare. Most of the fragments appear to belong to the large smooth form characteristic of the *Marsupites* zone. A few poorly preserved specimens resembling *I cripsi* have also been found. Very rare needle-like teeth of one of the Salmonidae, resembling those of the genus *Apateodus*, have been found in the lower portion of the *Marsupites* zone, as well as rare posterior plates of an amphineuran.

At Musk's Chalk, about 130 chains east of the railway station and a short distance north of the Mooliabeenie road, about 6 feet of chalk was exposed in a cut, apparently just above the top of the Molecap Greensand. About 1½ feet was also exposed in a second small cut, the top of which was about 12 feet above the base of the first. When last visited by the writer, both cuts were largely obscured by soil and vegetation. The rock consists of fine-grained greyish glauconitic chalk with very few quartz grains and appears to be mainly, if not wholly, in the *Uintacrinus* zone, as, so far as I know, *Marsupites* has not been found here, whereas plates of *Uintacrinus* are common in the lower cut. A well-preserved specimen of *Spondylus ginginensis* was found in highly glauconitic chalk at the base of the lower cut about 40 years ago by the late Dr. E. S. Simpson, as well as portion of a gastropod resembling a *Pleurotomaria* in brown weathered greensand, probably from just below the chalk. Only *Cidaris* spines and fragments of *Inoceramus* were seen in the higher cut.

At One Tree Hill, just over a mile north-north-west of the railway station, the thickness of chalk and chalk soil is about 18 feet. The junction between the chalk and the Molecap Greensand is exposed behind an old lime-kiln on the southern slope below the quarry. Here, it is abrupt and well defined, suggesting that some of the lower chalk is absent, though perhaps not as much as at Molecap. The Molecap phosphatic layer is absent here. The junction is also exposed near the base of a small cut on the south-eastern slope of the hill. Here the junction is very irregular, suggesting the presence of local currents. Fossils found in this cut include *Porosphaera globularis* and casts of other small sponges, *Coelosmilia ginginensis*, rare plates of *Holaster*, very numerous plates of *Uintacrinus*, *Kingena mesembrinus*, *Ostrea etheridgei*, *Pycnodonta ginginensis*, and large shark teeth, as well as a few coprolites.

The main quarry is 8 feet to 9 feet deep, the top being about four feet below the highest point of the hill. It was somewhat deeper at the south-west corner, now partly filled in, where plates of *Uintacrinus* are common in the darker grey, more glauconitic chalk. Many fossils were obtained during the excavation of the quarry. Glauert (1910, p. 117) stated that "the large Lamellibranchs are found in the upper portion of the main bed, and seem rare or entirely absent in the lower strata, where dwarfed Corals, Brachiopods, Lamellibranchs and Gastropods, as well as numerous Serpulae and Echinoderm spines represent . . . . . the animal life of the day . . . . ." Good specimens of ammonites are said to have been found near the south-western corner, as well as a very few well-preserved echinoids resembling *Holaster* and *Hemiaster*. *Marsupites* has been recorded from the quarry, but appears to be very scarce.

The upper portion of the quarry is in fine-grained white chalk, which differs from that of the other exposures in the occurrence, in places, of fairly numerous tabular, lenticular layers of indurated and probably silicified chalk, usually thin, but up to 6 or 7 inches thick in places.

Southern's Chalk is situated about 2¾ miles north-north-west of the railway station, about 50 chains north-west of the head of McIntyre Gully, and immediately north of the northern boundary fence of the Strathalbyn property. It is in a small gully which runs north from the fence to join a more mature west-running gully 194 feet farther north. The junction of the chalk with the Poison Hill Greensand is exposed a few feet north of the fence. The chalk, of which a thickness of about 12 feet is exposed, differs from that of the other exposures, consisting of a very fine-grained even-textured fairly dark grey to putty-grey rock, with much glauconite in fine grains.

The relative position of Southern's Chalk is not easy to determine, as neither *Marsupites* nor *Uintacrinus* has been found here. Although actually situated at a lower level than Hosking's Chalk, 32 chains farther north, it appears to represent a higher horizon, which may have reached its present position by slipping. The only fossils of index value found by the writer were a single small left valve of *Ostrea philbeyi*, associated with *Pycnodonta ginginensis*, from about four feet below the top of the chalk, and two faintly plicated small rhynchonellids from 6 or 7 feet below the top. These suggest that the exposure extends from about the middle of the *Marsupites* zone to about 7 feet above that zone, and that, compared with McIntyre Gully, about 45 feet is missing from the top of the chalk. Other fossils found here include a fairly large rudistid from about 6 feet below the top; some large *Pycnodonta* and *Kingena* from between 5 feet and 7 feet; also a few specimens of *Bouchardiella* and *Ostrea etheridgei*, and the posterior plates of an amphineuran. A large capillate *Magnithyris*, associated with unusually large specimens of *Inopinatarcula acanthodes* was found a little lower down.

The Springs Gullies are situated on the lower slope of the escarpment between 60 and 70 chains north-west of the head of McIntyre Gully and about 25 chains north-north-east of Southern's Chalk. They include three fairly deep narrow gullies which owe their origin to springs emerging at a few feet above the top of the chalk. They run westward to join a rather more mature gully from farther south, which, in turn, runs north-westerly to join a still older gully from the north-east. The junction of the Gingin Chalk with the Poison Hill Greensand is well exposed near the heads of the two more northerly of the three small gullies, which also give the best exposures of the chalk. The chalk here is coarse-grained and highly glauconitic, especially near the top. Specimens of the small, finely ribbed rhynchonellid found between 23 feet and 28 feet above the base of the chalk in McIntyre Gully are common between the top of the chalk and 6 feet below, associated with many relatively large specimens of *Bouchardiella* and a few tiny *Terebratulina*. *Spirulaea*, *Kingena* and *Inopinatarcula* were found at about 6 feet in the middle gully. Fossils found below 6 feet in the more northerly gully include *Serpula*, *Spirulaea*, a small conical sponge, *Kingena*, *Inopinatarcula*, *Magnithyris* and numerous *Plicatula*. A single small valve of *Ostrea philbeyi*, associated with a fairly

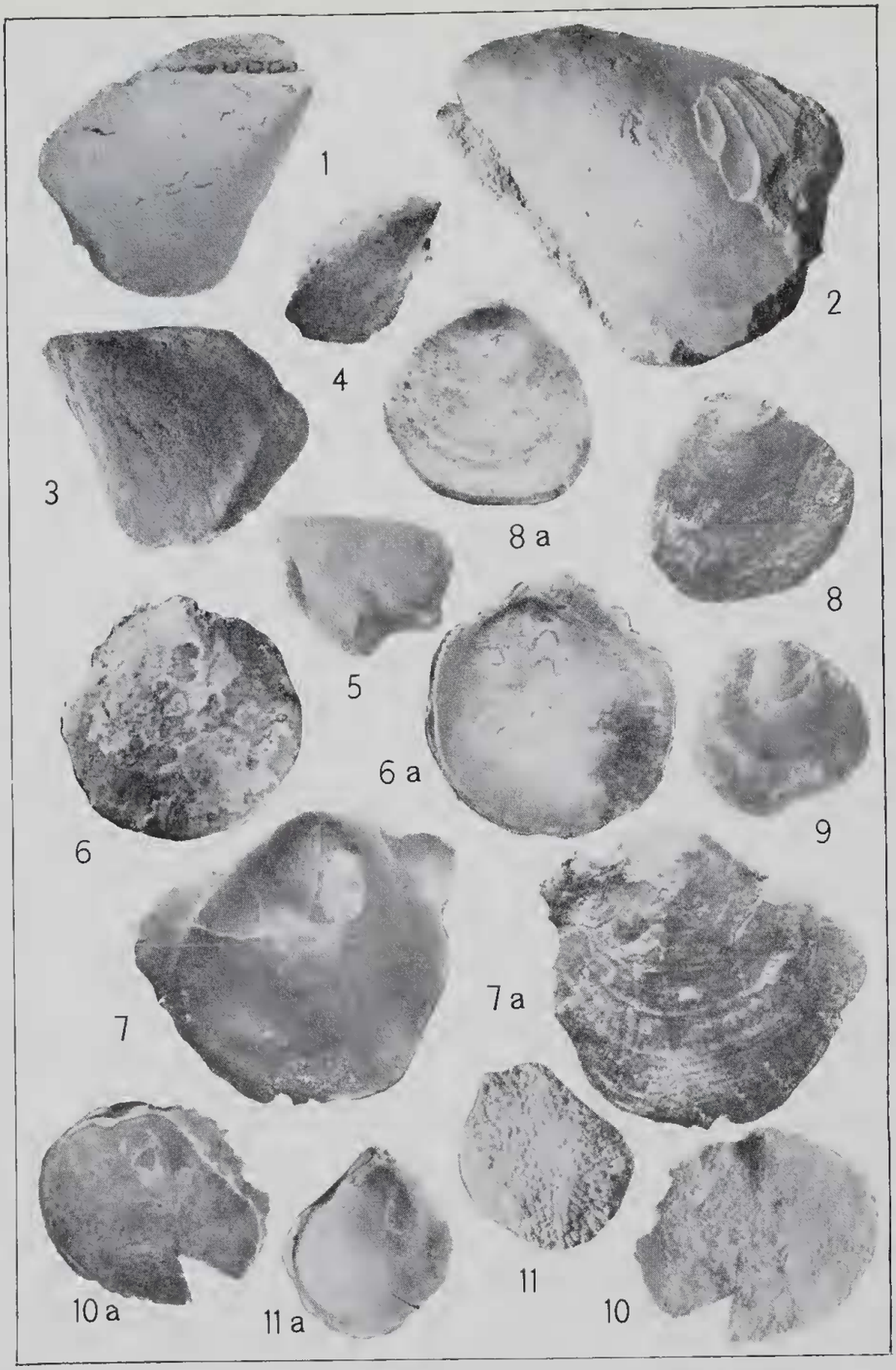

PLATE I

Perna coolyenensis

1.—The holotype (48932); cast of right valve and ligament pits of left valve, X 1½; 2.—The same (48932), left valve, further enlarged to show pattern of shell fragment, X 2; 3.—Paratype (48933): cast of left valve, X 1½; 4.—Cast of small right valve, X 1½; 5.—Cast of small left valve, X 1½. (All from Molecap.)

Anomia fragilis

6.—Exterior; 6a.—Interior of holotype (48936), a left valve, X 3; 7.—Exterior; 7a.—Interior of paratype (48937), a very large right valve, X 2; 8.—Exterior; 8a.—Interior of a smaller right valve, X 3; 9.—Exterior of a very small right valve (48938), with well-developed umbo, X 3. (All from McIntyre Gully.)

Anomia prideri

10.—Exterior; 10a.—Interior of holotype, a left valve (48939), X 2; 11.—Exterior; 11a.—Interior of a right valve, the exterior covered by a colony of bryozoans (48940), X 2. (Both from McIntyre Gully.)

large *Pyenodonta* was found at about 8 feet below the top, and also portion of a new *Chlamys*. A fragment of the carapace of a new crustacean was also found. Tiny specimens of *Magnithyris* and *Terebratulina* were found just below 9 feet. The horizons at which the index fossils were found suggest that approximately 40 feet is missing from the top of the chalk.

Hosking's Chalk is situated at the top of the western end of a long spur which runs west from the escarpment north of the Springs Gullies. It is 32 chains north-west of Southern's Chalk and one mile north-west of the head of McIntyre Gully. Only about six feet of chalk is exposed here, about half being in the *Uintacrinus* zone and half in the *Marsupites* zone. The exposure has proved to be fairly rich in the commoner fossils found at this horizon. Rarer forms found here include a few small smooth rhynchonellids, many *Magnithyris*, plates of both *Calantica ginginensis* and *Scalpellum glauerti*, small *Lamna* teeth, and one probably of one of the Salmonidae. Good specimens of *Plicatula glauerti* sp. nov. are fairly common, the holotype having been found here. The chalk is somewhat weathered, but still contains a fair amount of glauconite. A large percentage of yellowish quartz, in small grains, is also present.

The northernmost exposure, the North Chalk, is situated about 3¼ miles north-north-west of the railway station, 15 chains north of Hosking's Chalk, and ¾-mile south-east of Poison Hill. It consists of fairly coarse-grained chalk, somewhat similar to that of Hosking's Chalk but slightly more weathered and containing a larger proportion of evenly distributed grains of glauconite and rather larger grains of yellowish quartz. A thickness of only about three feet of chalk is exposed here, at the junction of the *Uintaerinus* and *Marsupites* zones. The fossils are much weathered. The assemblage appears to be similar to that of Hosking's Chalk. Rarer forms include part of a valve of *Spondylus ginginensis*, wholly attached to a fragment of *Inoceramus*, *Syncyclonema perspinosus*, *Pseudamussium candidus*, *Ostrea macintyrei*, and two unusually large cirripede keel plates, possibly of a new species.

Systematic Descriptions

Superfamily	...	PTERIACEA
Family	..	PERNIDAE, Zittel
Genus	.. ....	Perna, Bruguière, 1789

Perna coolyenensis,* sp. nov.

Plate 1, Figs. 1-5

The available material consists of three fairly large and three smaller casts, all more or less imperfect. The only fragment of shell remaining is on the left valve of the holotype near the posterior ventral margin. Five of the specimens are from Molecap and the sixth is probably also from the same locality. I have not found the species elsewhere. Approximate original dimensions are given in Table I.

* Coolyena—The name of the former trigonometrical station on Molecap Hill and probably the aboriginal name.

TABLE I

Approximate original dimensions of *Perna coolyenensis*, sp nov.

	Holotype 48932† Molecap		Paratype 48933 Molecap		48935 Molecap		48934 Molecap
	R. valve	L. valve	R. valve	L. valve	Very imperfect R. valve	L. valve	Small R. valve
	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Height	26	26+	25·5	?	27	?	17
Length	20·2	19·1	20	18·5	16?	16	11?
Thickness	10·1		9·1				

Hinge of left valve of holotype, 16 mm.

Description.—Shell of moderate size, the test thin and fragile; nearly equivalve, inequilateral, height greater than length, both valves moderately inflated, the right valve very slightly more so; beak sharp, apical angle about 65°; hinge-line long and straight, multivincular, postero-ventral margin rounded, anterior margin slightly concave to nearly straight, posterior margin slightly convex and forming a very obtuse angle with the hinge-line. Surface of test with low, somewhat irregular but clearly defined growth-lines, about 2 to 2½ mm apart at their widest on the holotype. Length of hinge nearly two-thirds the height of the shell. The interior of the hinge of the left valve of the holotype, 16 mm in length, is exposed to show six U-shaped ligament pits.

Remarks.—The Gingin specimens show some variation in shape. The holotype and paratype show a slight resemblance to the casts from the Cambridge Greensand figured by Woods (1905, p. 94), the holotype particularly to figure 19C, which, according to Woods, was referred to *P. lanceolata* Geinitz by Seeley, and to figure 19D, *P. semielliptica* Sceley and the paratype to figure 19F, referred to *P. subspathulata* Reuss by Seeley. The ventral portion of the Gingin species is, however, relatively wider than that of *P. laneeolata* and the anterior and posterior margins are straighter than those of *P. semielliptica* and *P. subspathulata* and the hinge-line appears to be longer than those of the English specimens. The third large cast from which the beak and posterc-ventral portion are missing was apparently relatively narrower than the others and more nearly resembles a specimen of *P. raulineana* d'Orb., figured by Woods (1906, Plate XII, Fig. 9), as does the small right valve, of which, however, the ventral portion is less produced.

The small right valve is the only specimen of which the horizon was recorded. This was the lower portion of the *Marsupites* zone, at five feet above the base of the chalk. The other specimens most probably came from about the same horizon.

Superfamily	ANOMIACEA
Family	ANOMIIDAE Gray
Genus	ANOMIA Linné, 1758

† Registered number, Geology Department Collection, University of Western Australia.

Anomia fragilis, sp. nov.

Plate 1, Figs. 6-9

Eighteen specimens, mostly small and some poorly preserved, were available for examination. These included ten from McIntyre Gully and eight from Molecap. Dimensions are given in Table II.

TABLE II

Dimensions of *Anomia fragilis*, sp. nov.

	Holotype 48936	Paratype 48937	Paratype 48938	Shell and cast		
	L. valve	R. valve	R. valve	R. valve	L. valve	R. valve
	mm.	mm.	mm.	mm.	mm.	mm.
Height	10·6	19·7	9·9	16·1	12·5	7·5
Length	10·1	22·0	10·0	16·5	10·8	7·4

Description:—Shell rather small, thin to moderately thick, disc sub-circular, ovate, to subtrigonal in shape, relative proportions of height and length variable, usually slightly inequilateral; nearly equivalve, slightly convex, usually most inflated near the dorsal margin. Disc surrounded by a thin flange, apparently of varying width, but very imperfect in the specimens examined. Umbo small, at or near the margin. Hinge very narrow, edentulous. Holotype decorated with a number of well-defined, rather irregular overlapping concentric lamellae of varying width and traces of indistinct and rather irregular radial striae near the ventral margin. Interior of right valve shows nearly circular depressed muscle area, immediately below the hinge, about 6½ mm in height on the holotype, with a large well-defined elongate elliptical adductor scar, situated immediately posterior to the median line and extending practically to the posterior edge of the muscular depression. The edge of the disc is marked by well-defined ridge, apparently strongest on the postero-dorsal portion. The pallial line is simple and fairly well defined. Interior of the disc generally smooth, rarely showing faint concentric ridging near the ventral margin.

Left valve shows depressed nearly circular muscle area about equal in height to one-third the height of the shell, but with a U-shaped extension from its posterior end, extending ventrally to about half-way down the shell. Major byssal scar, elliptical in shape, high up under the umbo and immediately anterior to the median line; nearly separated into two halves by a narrow, curving ridge which enters it from its posterior side. Adductor scar subtrigonal in shape, situated immediately below the major byssal scar; minor byssal scar not so well defined, apparently more nearly elliptical in shape and situated at a distance from the adductor scar a trifle greater than the width of either and dorsally of a line at right angles to a line running through the other two scars.

Remarks.—The largest right valve somewhat resembles in shape a specimen of *A. pseudoradiata* d'Orb. figured by Woods (1899, Plate VI, Fig. 2) but lacks the fine radial riblets of that species. It also resembles fairly closely *A. subtrigonalis* Meek and Hayden from the Fort Pierre group of the North America Cretaceous (Meek 1876, p. 22, Plate 16, Fig. 4a). Other specimens show a resemblance in shape to specimens of *A. ponticulana* Stephenson (1952, Plate 20, Figs. 1-4), but the umbo of that species is farther from the margin and the hinge is stronger.

At McIntyre Gully the range of the species is from the base of the chalk to 18 feet above. At Molecap, it has been found between one foot and seven feet above the base. Most of the specimens from Molecap are particularly fragile, especially the left valves, and it is almost impossible to obtain one intact.

Anomia prideri, sp. nov.

Plate 1, Figs. 10, 11

Two specimens from McIntyre Gully differ from those of the preceding species in their marked obliquity and in the greater depth of the hinge. The larger specimen (the holotype), a left valve, is from about 14 feet above the base of the chalk; the location of the smaller specimen, a right valve, was not recorded. Dimensions are given in Table III.

TABLE III

Dimensions of *Anomia prideri*, sp. nov.

	Holotype 48939	Paratype 48940
	L. valve	R. valve
	mm.	mm.
Height	14·0	12·5
Length	15·8	11·0

Description.—Shell fairly small and moderately thin, obliquely ovate to piriform, inequilateral, the anterior half being somewhat the larger. Proportions of height to length variable, both valves slightly convex, the right valve rather more so. Umbo very small, marginal, directed slightly anteriorly. Hinge edentulous fairly thick and deep, particularly posterior to the umbo. Exterior surface of holotype nearly smooth, that of the paratype is almost wholly obscured by a colony of tiny bryozoans. Pallial line simple and well defined.

Interior of right valve smooth, the muscle attachment area only very slightly depressed, with the large elliptical adductor scar immediately posterior to the median line and extending from about 2.5 to 5 mm below the umbo. The interior surface of the left valve is much eroded. The anterior margin of the specimen shows the remnants of a fairly wide flange; 6 or 7 tiny crenulations are present immediately below the hinge on the ridge separating the body of the valve from the flange. The muscular area, circular in shape, extends to about half the height of the valve below the beak; the position and shape of the minor byssal and adductor scars are difficult to determine; the major byssal scar is slightly larger than that of *A. fragilis;* it is situated a little below the hinge immediately posterior to the median line,

with the adductor scar at about half way down the muscle area below it and slightly anterior to it; the minor byssal scar is very faint; it appears to be larger than the adductor scar, circular in shape and situated nearly opposite the middle of the major byssal scar below the posterior portion of the hinge.

Remarks.—In its obliquity and shape, *A. prideri* resembles a species of *Anomia* from the Crackers of Atherfield, figured by Woods (1899, p. 28, Plate V, Figs. 4, 5) but it lacks the radial ribs of the English species. It also resembles somewhat some specimens of *A. psamatheis* Bayan from the Auverian and Bartonian of Aquitaine (Cossman 1922, p. 215, Plate XV, Figs. 23-25) but the shape of the muscular area appears to be different.

Superfamily .	PECTINACEA
Family . .	SPONDYLIDAE
Genus	SPONDYLUS Linné, 1758

Spondylus ginginensis, sp. nov.

Plate II, Figs. 1, 2

Represented by four more or less imperfect specimens of united valves of varying size, three from Molecap and one from Musk's Chalk, as well as a small imperfect right valve showing the interior and wholly attached to a fragment of *Inoceramus* from the North Chalk. Dimensions are given in Table IV.

TABLE IV

Dimensions of *Spondylus ginginensis*, sp. nov.

	Holotype 48941 Molecap		Paratype 48942 Molecap		Molecap		48943 Musk's Chalk	
	L. valve	R. valve	L. valve	R. valve	L. valve	R. valve	L. valve	R. valve
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Height	45·6	51·5?	37·3	40·8?	30·2	36·4	29·0	32·5
Length	40·9	44·0?	35·2	37·0?	28·0	?	28·2	26·6
Thickness	33·6		28·3		14·0		20·7	

Description.—Shell fairly large, ovate, oblique, height greater than length, the left valve usually highly inflated, the right valve less so, but higher and perhaps slightly wider. Attached by the right valve, usually by the umbonal part only, this part usually much produced, some specimens showing a marked gap between the umbones of the two valves. Exterior surfaces of both valves ornamented with 70 to 80 fine evenly-spaced radial threads, and rather indistinct concentric growth lamellae; fine concentric threading, more noticeable on the right valves, is also present. A number of irregularly spaced small spines are present on the dorsal half of the left valve of the paratype.

Left valve usually highly convex, the beak terminal and sharp, and curved approximately at a right angle to the commissure. Postero-dorsal margin of body of shell, where joined by ear, concave, the anterior and ventral margins convex. Ears descending slightly from the umbo; posterior ear large, extending on the holotype, from the beak to 24 mm below; dorsal margin straight, distal margin concave; anterior ear smaller, extending to 17 mm below the beak, dorsal and distal margins straight, meeting at a very obtuse angle. On the paratype the width of the posterior ear is about 8 mm. Both ears show faint concentric threading continued upwards from the body of the valve. The left valve of the holotype is ornamented with about 80 radial threads. On the other specimens the number is about 70.

Right valve less convex than the left, but considerably higher and apparently slightly longer. The umbo is produced well above that of the left valve. The area of attachment is very variable in size; on the holotype the attachment is to a smooth surface of *Inoceramus*, on the paratype the umbonal half of the attached portion shows fine radial ribbing, the other half well marked concentric lamellae; the other two specimens do not show any area of attachment. Ornament similar to that of the left valve, except that spines appear to be absent.

Remarks.—The third specimen of which the dimensions are given is much flatter than the others, its thickness being only half the dimension of the length of the shell, whereas in the other specimens the proportion is three-quarters. It may represent a different species, but in some European species the proportions of thickness to length appear to be variable. In the Musk's Chalk specimen, the point of greatest width is situated higher than in the other specimens. *S. ginginensis* appears to resemble most nearly the European species *S. gibbosus* d'Orbigny, particularly the specimens from the Cambridge Greensand figured by Woods (1901, Plate XX, Figs. 5-11), but the right valves of the Gingin specimens are relatively flatter, except in the Musk's Chalk specimen, and the ears of the left valves appear to be larger. Woods (1901, p. 118) states that the right valve of *S. gibbosus* is variable, flattened when attached by its entire surface, more convex when attached by a part only. The regularly spaced stronger ribs found on some specimens of *S. gibbosus* (Woods 1901, Fig. 5) are absent from the Gingin specimens.

The holotype of *S. ginginensis* was found in a block of chalk that had fallen from the back of the Molecap quarry. The paratype was from 2 ft 6 ins. above the base of the Gingin Chalk, at the junction of the *Uintacrinus* and *Marsupites* zones. Judging from the dark brown colour of the test, the Musk's Chalk specimen must have come from near the base of the formation at that locality. The North Chalk specimen was from the junction of the *Uintacrinus* and *Marsupites* zones. The range of the species would appear to be the *Uintacrinus* zone and lower half of the *Marsupites* zone. Four imperfect right valves, wholly attached to fragments of *Inoceramus*, similar to the North Chalk specimen, were found by Dr. Glenister and Mr. Balme in the Toolonga Calcilutite of the Murchison River valley at Thirindine Point and a similar fairly large specimen was obtained by Clarke and Teichert from Pillarawa Hill farther north, as well as two small ones from Meanarra Hill south of the Murchison River.

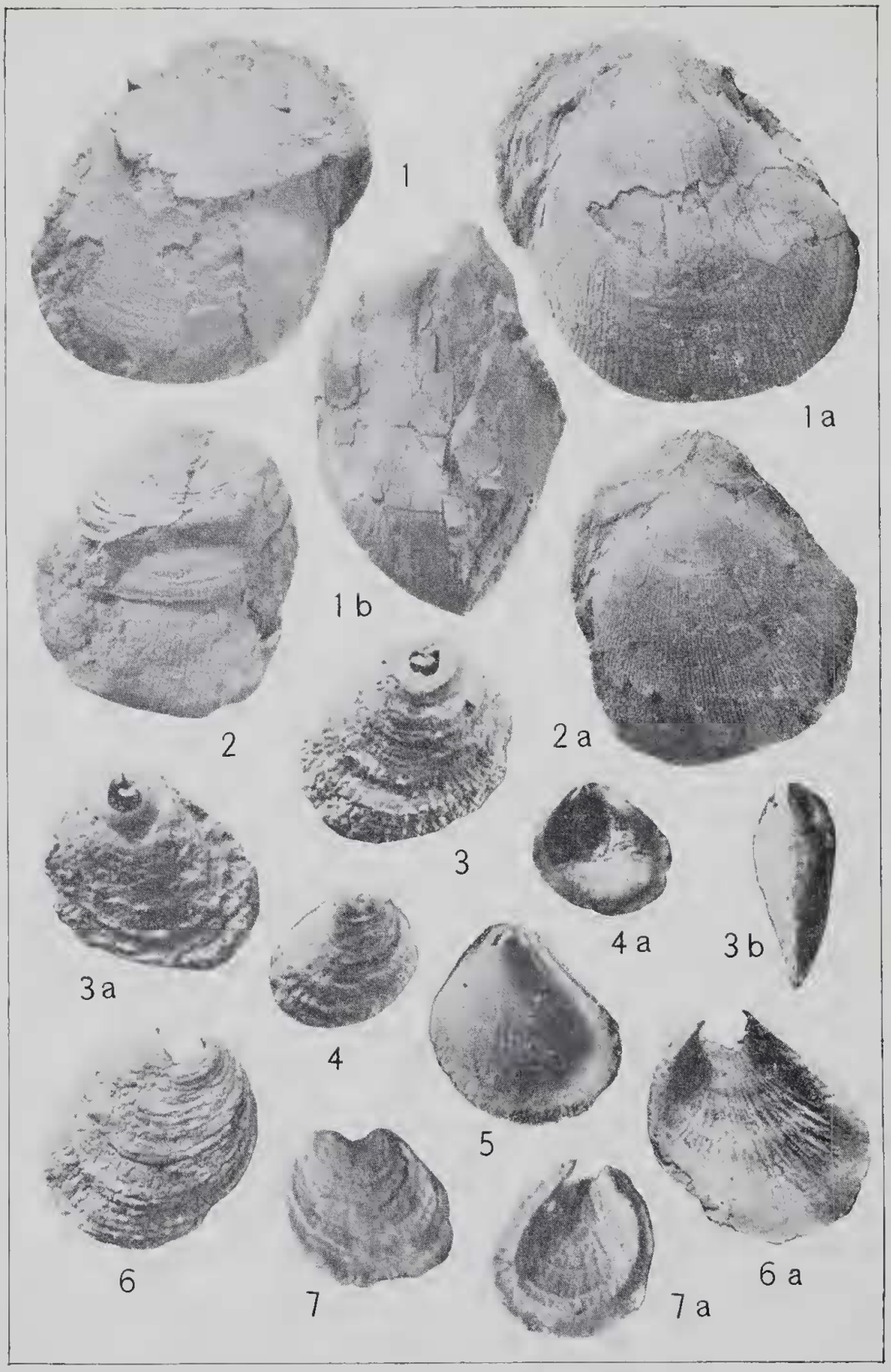

PLATE II

Spondylus ginginensis

1.—Right valve of holotype (48941), from Molecap, nat. size; 1a.—Left valve of same (48941), nat size; 1b.—Posterior profile (48941), nat. size; 2.—Paratype, right valve (48942), nat. size; 2a.—Paratype, left valve (48942), nat. size.

Plicatula glauerti

3.—Right valve of holotype (48944); 3a.—Left valve; 3b.—Posterior profile, Hosking's Chalk, X 3; 4.—Exterior of paratype, a right valve (48947); 4a.—Interior, showing teeth, Molecap, X 3; 5.—Interior of right valve, with teeth, Middle Springs Gully (48946), X 3; 6.—Exterior of imbricated right valve (48948); 6a.—Interior showing anastomosing ribbing, McIntyre Gully, X 3; 7.—Exterior of a left valve (48945); 7a.—Interior showing ribbing, Hosking's Chalk, X 3.

Genus PLICATULA Lamarck, 1801

Plicatula glauerti, sp. nov.

Plate II, Figs. 3-7

About 150 specimens, mostly right valves, from various exposures, were available for examination. Left valves are comparatively rare and I have only seen three specimens of united valves. The hinge with the characteristic *Plicatula* teeth was preserved in only four right valves. The umbo was absent from nearly all the specimens. Dimensions are given in Table V.

TABLE V

Dimensions of *Plicatula glauerti*, sp. nov.

	Holotype 48944		Paratype 48947	Paratype 48946	Imbricated 48948		48945	Molecap
	Hoskings Chalk		Molecap	Springs Gullies	McIntyre Gully		Hoskings Chalk	
	R. valve	L. valve	R. valve (with teeth)	R. valve	R. valve	L. valve	L. valve	L. valve
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Height	9·5	9·1	6·0	9·0	10·0	8·3	7·5	6·0
Length	8·8	8·7	6·1	8·5	9·3	8·1	6·7	6·9

The thickness of the united valves of the holotype is 3.9 mm.

Description.—Shell small, obliquely ovate to broadly piriform, the degree of obliquity varying; height and length nearly equal, but height usually the greater; inequivalve, the right valve moderately to strongly inflated except where wholly attached, the left valve rather less so. Attached by the right valve, but individual specimens range from unattached to wholly attached; in many, the area of attachment appears as a small subcircular truncation of the umbonal area; this is present in about 40 of the specimens examined; margins rounded. Body of shell thin near the umbo, thickened at the margins, especially the ventral margin, the width of the thickened portion varying considerably. Pallial line simple, well-defined on better preserved specimens.

Right valves range from those in which the whole exterior surface is covered with from about 20 to 40 closely spaced small radial riblets or plications to those from which radial ornament is absent; the riblets may be confined to the ventral half of the shell. They usually become obsolete near the anterior and posterior margins. Very rarely a single rib bifurcates near the ventral margin. The ribbed forms appear to predominate, although ribless specimens are fairly common. Concentric ornament of a number of closely spaced slightly irregular growth rings, of which from three to five may be more prominently imbricating. The interior surface appears to be slightly eroded as I could find no trace of an adductor scar on any of the specimens, the innermost layer of the shell apparently consisting of more soluble material. The interior decoration visible consists of 16 to 20 rather irregular bifurcating riblets. The hinge shows the typical divergent teeth, of which the anterior is slightly the longer. The left valves are usually more nearly circular in outline, and are less inflated than the right valves, and very rarely may be even slightly concave; radial ribs are absent, the valves showing only concentric ornament, similar to that of the right valve. Where the hinge is present there is usually a nearly circular hole immediately below. The interior decoration consists of 15 or 16 anastomosing riblets. On some small specimens the interior ribbing is very indistinct, the ornament consisting of four or five concentric threads.

Remarks.—*Plicatula glauerti* is one of the commonest Gingin fossils and has a wide vertical range extending, at McIntyre Gully, from the base of the chalk to about 43 feet above. It is particularly common at Molecap and Hoskings Chalk and has been found at the Springs Gullies and the North Chalk, but, so far, I have not found it at One Tree Hill or Southern's Chalk.

In general appearance and in type of ribs the Gingin species most nearly resembles the European Cretaceous species figured by Woods, *P. minuta* Seeley (16-20 ribs) and *P. barroisi* Peron (13-25 ribs) (Woods 1901, p. 138, Plate XXV, Figs. 22-25 and pp. 141-143, Plate XXVI, Figs. 12-18 respectively), particularly the former species. Woods says that it seems probable that *P. minuta* is only the young form of *P. gurgites* (Woods, 1901, Plate XXV, Figs. 13-21) but that species shows little resemblance to the Gingin shell. *P. glauerti* is, however, considerably larger than *P. minuta* and its ribs are usually more numerous. *P. barroisi* also is smaller than the Gingin species, its ribs are usually fewer, and bifurcation of the ribs is common.

The Gingin species also resembles fairly closely specimens of the supposed genus *Diploschiza,* founded by Conrad on imperfect specimens of a single species *D. cretacea* Conrad and revived by Stephenson (1934, pp. 273-280, Plate 38). The Gingin shells are rather more oblique than those of Conrad's species and plicated specimens resembling those of Stephenson's variety *D. cretacea striata* (Stephenson 1934, Plate 38, Figs. 15-17) are more common; also the ribless form of the Gingin species appears to be rather more rugose than Stephenson's neotypes (Stephenson 1934, Figs. 3-9). Stephenson's specimens were from the southern extension of the Pecan Chalk Member of the Taylor Marl of Texas.

The genus *Diploschiza* was founded on specimens of which the hinge was imperfect and from which the innermost layer of the shell was missing. According to the description of the genus given by Shimer and Schrock (1944, p. 407) teeth are absent, and the inner surface of both valves is lined to near the margin with fine sharp irregularly spaced radiating ridges. Stephenson (1934, p. 276) stated that the hinge is edentulous, but also mentioned that "an occasional right valve supported by the fragment of extraneous shell to which it is attached exhibits a faint suggestion of a pair of small short crural ridges diverging inwardly" (the *Plicatula* teeth). He suggested that the absence of muscle scars on the inner surfaces

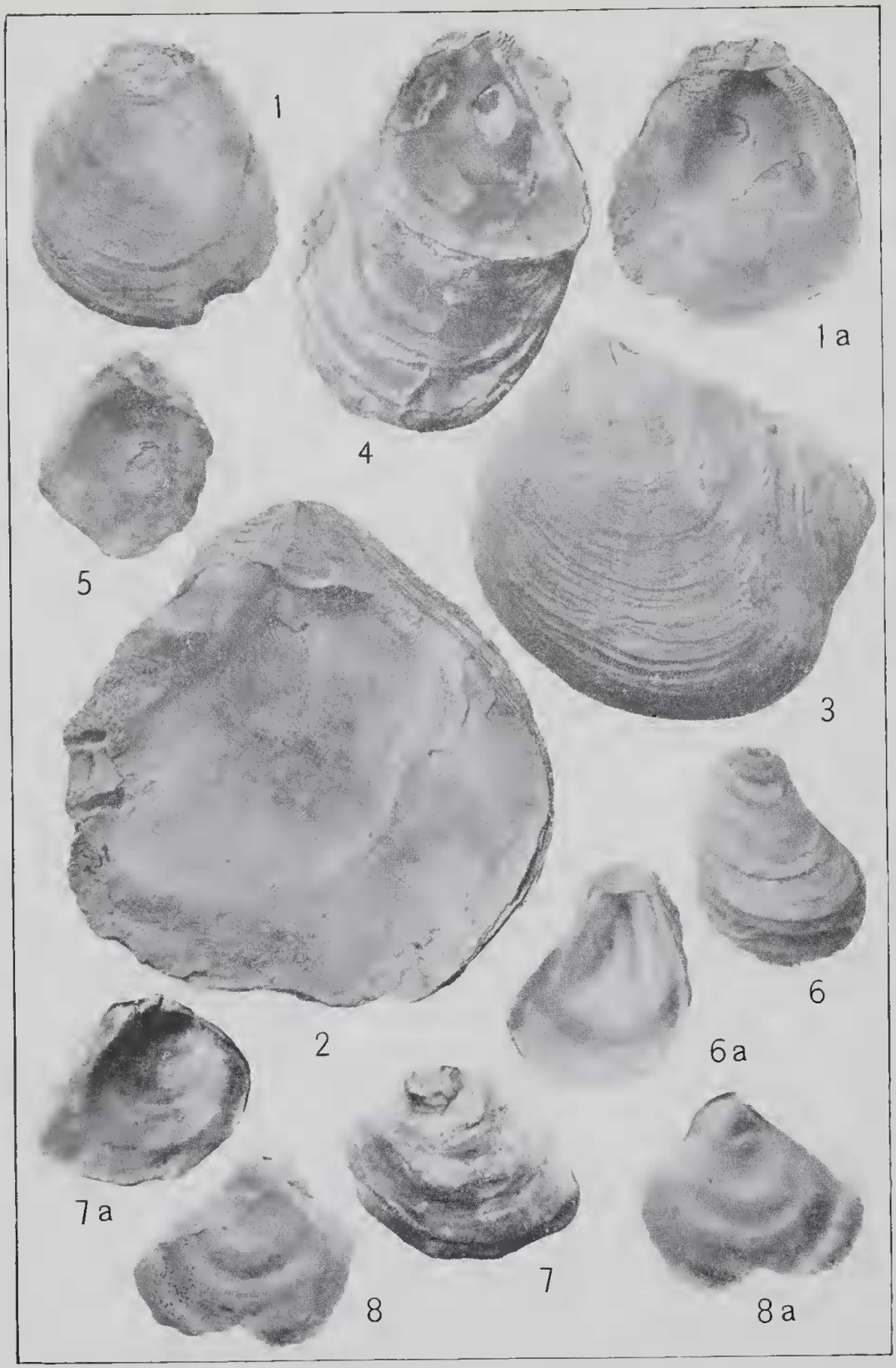

PLATE III

Ostrea philbeyi

1.—Exterior; 1a.—Interior of holotype: a left valve (48950), nat. size; 2.—Interior of a left valve: the largest specimen seen (48957), nat. size; 3.—Exterior of a slightly alate left valve (48958), nat. size; 4.—Interior of a right valve attached to a larger left valve (48951), nat. size; 5.—Interior of a small right valve (48952), nat. size. (All from McIntyre Gully.) 6.—Exterior; 6a.—Interior of a small left valve (48954). Nungajay Springs area, 8½ miles N. of the mouth of Murchison River. Nat. size.

Ostrea macintyrei

7.—Exterior; 7a.—Interior of holotype, a left valve (48955), x 2; 8.—Exterior; 8a.—Interior of a small right valve (48956), X 3. (Both from McIntyre Gully.)

"may be due to the failure of preservation of a thin inner layer of the shell." This is a regular feature of the Gingin species and Eudes-Deslongchamps (1858, p. 2) has mentioned that some of the *Plicatulas* from the neighbourhood of Caen were greatly attenuated in the cardinal region, and did not show in the interior any trace of teeth, groove, ligamental cavity, or muscular impression, the interior surface showing only growth striae, whereas others, from rocks of a different character, with thick test in the cardinal region showed the muscle impression, the teeth and groove. He attributed the different states of preservation of the two groups to their occurrence in rocks of different character.

Without doubt the shells of Conrad's species are really *Plicatula* from which the teeth and innermost layers of the shell have been eroded. Therefore, as a generic name *Diploschiza* is invalid.

The wholly attached valves of *P. glauerti* are most commonly found on nearly flat surfaces such as fragments of *Inoceramus,* valves of *Ostrea philbeyi* and right valves of *Pycnodonta ginginensis,* but I have found them also on *O. etheridgei,* on a larger *Plicatula* and even on the small brachiopod *Bourchardiella cretacea.*

Superfamily	.	OSTREACEA Goldfuss
Family	.	OSTREIDAE Lamarck
Genus	..	OSTREA Linné, 1758

Ostrea philbeyi,* sp. nov.

Plate III, Figs. 1-6.

Ostrea sp. *a.* R. Etheridge, Junr., Geol. Surv. W. Aust. Bull. No. 55, p. 17, Plate IV, Figs. 8, 9, 1913.

Etheridge's brief mention of this species is: "A single example of a very thin-shelled flat valve, of common form and with no particular characters. The type is, however, new to our Cretaceous rocks, and therefore of interest, but resembles an Oyster met with in the oolitic beds of the Greenough River." His excellent drawings are of a fairly well-preserved specimen a trifle more oblique than the holotype.

A fairly large number of specimens from McIntyre Gully, nearly all left valves and mostly somewhat eroded, was available for examination, as well as single small left valves from Southern's Chalk and the northernmost of the Springs Gullies. Right valves are comparatively rare and only four were available. Dimensions are given in Table VI.

All specimens from McIntyre Gully except 48954 which is from Nungajay, Murchison River area.

Description.—Shell fairly large, moderately thick, ovate, slightly oblique, height slightly greater than length, nearly equivalve but the right valve may be slightly smaller than the corresponding left valve, inequilateral, rarely alate. Left valve slightly inflated, right valve nearly flat. Umbo straight, or slightly curved, fairly sharp when well-preserved, left valve occasionally showing small area of attachment. Ligamental groove broadly triangular; ligamental area large, with well-marked transverse striae. Exterior surface fairly rough, with closely spaced rather irregular growth lamellae. Interior surface smooth except for the well-defined adductor scar. Depressed area for accommodating the body of the animal well-defined, extending below the umbo for about two-thirds of the height of the shell. On the interior of the valve the anterior submargin, immediately below the ligamental area, shows a line often to eighteen short transverse, rarely bifurcating crenulations extending usually to approximately opposite the top, rarely the middle, of the adductor scar. On the posterior submargin is a shorter, wider area of slightly waved crenulations. Adductor scar fairly large, nearly elliptical in outline, the centre situated from slightly less than one-third to about two-fifths the height of the shell below the umbo.

TABLE VI

Dimensions of *Ostrea philbeyi*, sp. nov.

	Holotype 48950	Paratype 48957	Alate 48958		48951	48954		
	L. valve	L. valve	L. valve	L. valve	L. valve with small R. valve attached	L. valve	Right valves	
	mm.	mm.	mm.	mm.	mm.	mm.	mm	
Height	37·8	65	52·5	50	46·7	30·5	38 +	32·5 27
Length	32·8	62	50·5	44	37	24·5	36?	30·6 24·5

Right valve usually flatter and thinner than the left. So far as could be judged from the poorly preserved specimens the exterior surface is smoother than that of the left valve. The crenulations on the interior submargins appear to be similar to those of the left valve. The position of the adductor scar varies considerably. On the two larger specimens and also on a small specimen (48953) from the *Marsupites* zone it is situated at about the same height as those of the left valves, but on the smallest specimen figured it is about half-way down the valve.

In Clarke and Teichert's large and comprehensive collection from the Murchison River area the only representatives of *O. philbeyi* are four small specimens from the Nungajay Springs area on the westward-facing escarpment about 8½ miles north of the mouth of the Murchison River. Two of these specimens are similar in shape to the McIntyre Gully specimens, but the other two, and particularly the one figured (Plate III, Figs. 6, 6a) are narrower and more obliquely piriform in shape; the anterior margin is curved inwards, the shell is much thicker, particularly the interior marginal portion enclosing the pallial line; and the exterior surface more rugose. These features suggest their growth in waters more disturbed by local currents than those in the McIntyre Gully area.

Remarks.—Etheridge (1910) stated that *O. philbeyi* resembled "an oyster met with in the Oolitic beds of the Greenough River," probably from the Newmarracarra Limestone, east

* After the late Mr. W. R. Philbey, who collected the specimens described by Mr. Etheridge.

of Geraldton. Etheridge's figure shows the interior of a right valve obliquely subtrigonal in outline (Etheridge 1910, Plate IX, Fig. 2). The specimen does not show the large triangular ligamental area characteristic of *O. philbeyi* and the adductor scar is larger, apparently less deeply cut, more centrally situated and more nearly circular in outline.

The Gingin species somewhat resembles the European *O. leymerii* Leymerie (ex Deshayes) (Woods 1912, pp. 355-358, text-figs. 139, 140) but the latter is a much larger and apparently thicker shell. In shape and size *O. philbeyi* most nearly resembles the widely spread *O. acutirostra* Nillson, especially to the rather poorly preserved specimens from the *Cardita beaumonti* beds of Baluchistan figured by Cossman and Pissaro (1927, Plate I, Figs. 1-5). Possibly owing to erosion, these do not show the ligamental groove and transversely striated area characteristic of *O. philbeyi*. The shells appear to be thicker, the adductor scar of the left valve is situated much lower than in the Gingin shell, being below the transverse median line and where the specimens are slightly alate, the alation is anterior instead of posterior. The slightly curved beak shown by some of the specimens from the Arrialoor beds figured by Stoliczka (1871, Plate XLV, Figs. 3 and 3a) is absent from the Gingin species. Stoliczka's specimens show the ligamental groove and area.

As far as I know, *Ostrea philbeyi* has not been found below the uppermost foot of the *Marsupites* zone, in which one small right valve was found, and at McIntyre Gully is practically restricted to a zone between about 21 feet and 23 feet above the base of the chalk. Although found in the main gully it is commonest in the second small eastern tributary. From its restricted occurrence, the species appears to be a good horizon marker.

Ostrea macintyrei, sp. nov.

Plate III, Figs. 7, 8

Ostrea sp. or *Pycnodonta* sp. (Juvenile form): R. Etheridge, Junr., Geol. Surv. W. Aust. Bull. No. 55, p. 19, p. 29, Plate III, Figs. 10, 11, 1913.

Etheridge's figures show a small right valve of which the original dimensions were apparently about 14 mm in height by 13 mm in length; unfortunately, the ventral portion is imperfect, and it is impossible to say whether the specimen was originally ovate or subtrigonal in shape Etheridge evidently regarded his specimen as a young form of some larger shell, but it was more probably an adult shell as the only other specimens that could be assigned to the same species are even smaller.

A single small left valve (48955), height 12.3 mm, length 14.2 mm, from McIntyre Gully at about 17 or 18 feet above the base of the chalk, doubtless belongs to the same species as Etheridge's specimen, as does a small right valve (48956), height 9.8 mm, length 10 mm, from about 19 feet above the base.

Description.—Shell small, fairly thin, both valves slightly convex, obliquely subtrigonal to ovate; length usually slightly greater than height, nearly equivalve, inequilateral, the posterior portion produced; umbo small, sharp, except where truncated by area of attachment; attached by the left valve; posterior margin straight and making an obstuse angle with the ventral margin, anterior margin rounded and passing almost insensibly into the ventral margin; exterior surface rugose with strongly marked concentric ridges and rather faint growth lamellae. Interior surface smooth, but shallowly grooved in harmony with exterior concentric ridges.

The left valve shows a small but prominent area of attachment immediately behind the beak. The exterior shows two fairly prominent rather irregular concentric ridges as well as fine, rather indistinct growth lamellae. The hinge is small and shows a rather narrowly triangular ligamental groove, and shallow triangular area on which transverse striae could not be detected. On the posterior submargin, immediately below the hinge, is a short, broad area showing three fairly strong dental crenulations, nearly parallel to the median line. A slightly longer line of crenulation is present on the much narrower anterior submargin. The interior of the valve is shallowly grooved in harmony with the exterior ridges. The adductor scar is fairly large, rather shallow, elliptical in outline, and is situated at a distance below the hinge nearly equal to its major diameter. The pallial line is well defined and remote.

Right valve similar in shape to the left. Its exterior also shows two low broad rounded concentric ridges separated by a narrow groove; growth lamellae very faint. The rather narrow ligamental area is very similar to that of Etheridge's specimen and does not show any defined groove. Interior of valve with faint grooves corresponding to the exterior ridges. Adductor scar rather small and very shallow, semi-elliptical in shape and situated at about one-third of the distance from the median line to the postero-ventral angle.

Remarks.—This species is very rare. The only two examples of which the locality is known are from the uppermost portion of the *Marsupites* zone. So far as I can determine it does not resemble any of the European Upper Cretaceous *Ostreidae*.

Ostrea etheridgei, sp nov.

Plate IV, Figs. 1-4

Ostrea sp. *b*. R. Etheridge, Junr, Geol. Surv. W. Aust Bull. No. 55, p. 17, Plate II, Figs. 19-21, 1913.

Etheridge stated:—"I have associated together a few very small and delicate valves, perhaps only the young of some larger form. They are rudely deltoid in outline, with high pointed umbos, and very short area. The adductor impressions, on the other hand, are large for such small shells. The two largest have lost much of the pointed umbo feature, and the valves have broadened out."

Etheridge's figures are of two small, rather squat specimens, not very characteristic in shape.

Right valves of this species are among the commonest Gingin pelecypods, but left valves are rare and I have only seen four small specimens, of which only one is reasonably well preserved. Dimensions are given in Table VII.

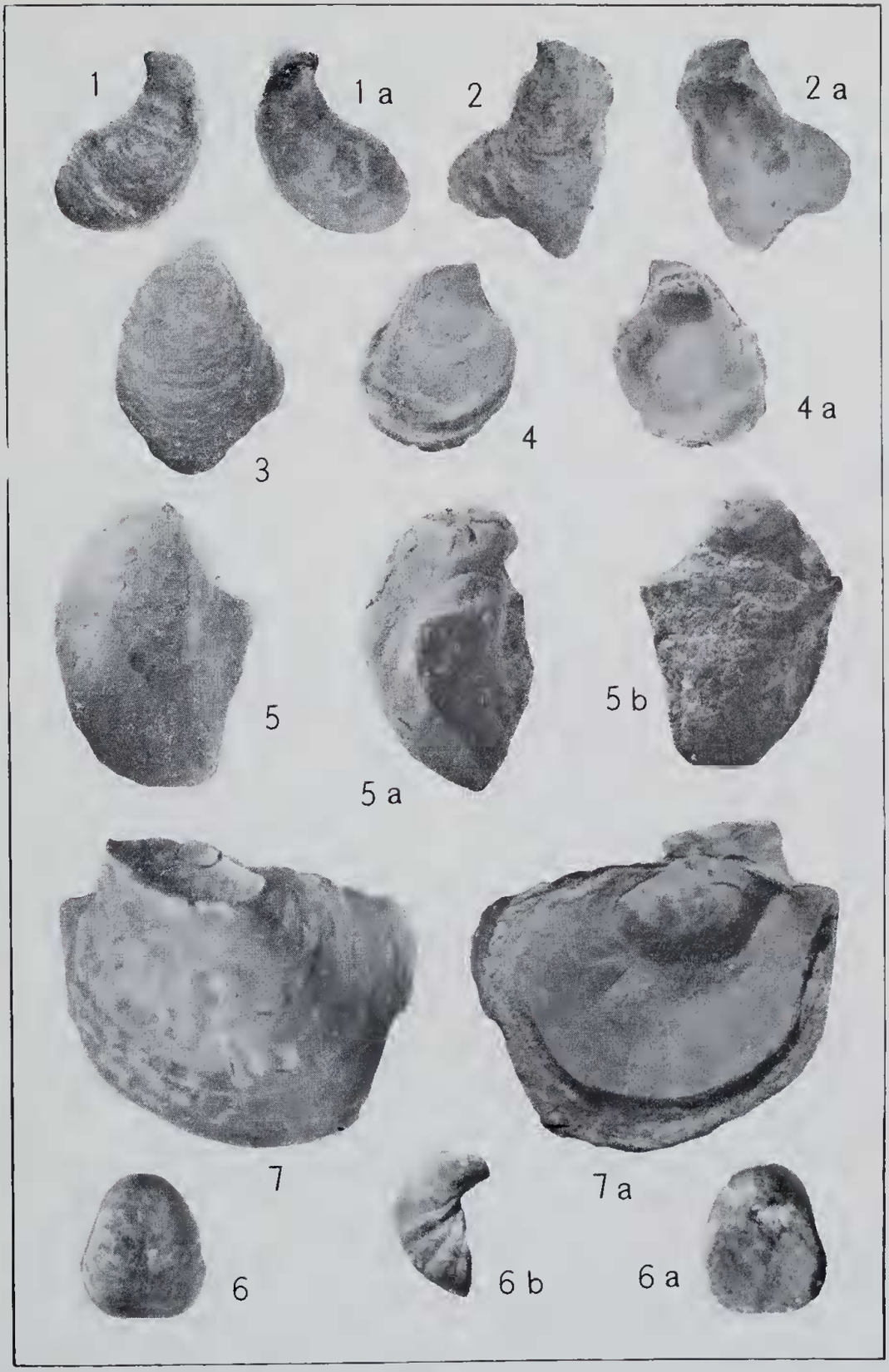

PLATE IV

Ostrea etheridgei

1.—Exterior; 1a.—Interior of holotype, a right valve (48959), X 2; 2.—Exterior; 2a.—Interior of paratype, a right valve (48960), X 2; 3.—Exterior of a large piriform right valve (48961), X 2; 4.—Exterior; 4a.—Interior of a small left valve (48962), X 3. All from McIntyre Gully except (48961).

Gryphaea teicherti (23025)

5.—Exterior of cast of a left valve, nat. size; 5a.—Posterior profile of same cast, nat. size; 5b.—Front view of cast, nat. size. Locality uncertain.

Gryphaea minuta (48964)

6.—Cast of left valve of holotype, X 4; 6a.—Cast of right valve of holotype, showing trace of test, X 4; 6b.—Posterior profile of holotype, X 4. From McIntyre Gully.

Pycnodonta ginginensis. Eth. fil.

7.—Left valve; 7a.—Right valve of a well-preserved specimen from Molecap (48965), X $1\frac{1}{2}$.

TABLE VII

Dimensions of *Ostrea etheridgei*, sp. nov.

	Right valves			Left valves			
	Holotype 48959 McIntyre Gully	Paratype 48960 McIntyre Gully	Largest Spec. 48961 Molecap	Paratype 48962 McIntyre Gully	Alate Molecap	48963 North Chalk	Molecap
	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Height	13·2	14·32	16·0	8·5	11·8	10·7	8·9
Length	8·2	9·7	11·35	6·5	12·0	10·0	6·9

Description.—Shell small, fairly thin, shape very variable, usually considerably higher than long, obliquely piriform or ovate, the degree of obliquity varying greatly, inequivalve, usually very inequilateral, rarely nearly equilateral; beak usually directed posteriorly, rarely upright; right valve slightly convex, left valve more so; ligamental area varying in depth.

Posterior margin of right valve usually strongly concave below the beak for about half the height of the shell, passing insensibly into the convex ventral margin, but it may be nearly straight or even slightly convex; anterior margin convex. The exterior surface slightly rugose to nearly smooth with numerous closely spaced growth lamellae. Interior surface smooth except for the unusually large, shallow, more or less elliptical or piriform adductor scar of which the centre is situated from a little more than three-fifths to nearly three-quarters of the distance from the beak to the ventral margin. Ligamental groove apparently absent; ligamental area varies somewhat in size, and usually shows faint transverse striae. Marginal crenulations are absent.

Left valve very similar in shape to right but considerably more convex. The paratype (Plate IV, Figs. 4, 4a) appears to show a small flattened area of attachment immediately below the beak. The ligamental area is relatively large. The adductor scar is very faint, but appears to be elliptical in shape, and situated immediately below the hinge-line and slightly nearer the median line than the posterior margin.

Remarks.—At McIntyre Gully, right valves of this species are common between the base of the chalk and 20 feet above. Above that horizon they appear to be rare, but have been found as high as 42 feet above the base. They are also common at Molecap and other exposures in the *Uintacrinus* and *Marsupites* zones.

Etheridge (1913, p. 17) compared the outline of this species with that of a specimen described by Meek (1876, p. 18, Plate XI, Figs. 4a, b) as *O. patina* var. C, but the latter is a much larger, coarser shell. There is also some resemblance to *Gryphaea arrialoorensis* Stoliczka (1871, p. 464, Plate XLV, Figs. 13, 14) but the left valves of that species appear to be more slender and more oblique than those of *O. etheridgei*.

On the whole the Gingin species appears to resemble most nearly the specimens of *O. incurva* Nilson figured by Woods (1912, Plate IX). Like those of *O. etheridgei* individual specimens of *O. incurva* vary greatly in shape, and except that the Gingin specimens do not show the radial riblets seen on some of Woods' specimens, especially his Figs. 12, 14 and 16, the resemblance is very close. The beak of *O. incurva*, however, appears on the average perhaps to be more sharply curved posteriorly and the adductor scar of the right valve is situated much higher and is more elliptical in shape than that of *O. etheridgei*.

Genus GRYPHAEA Lamarck, 1801

Gryphaea teicherti, sp. nov.

Plate IV, Figs. 5, 5a, 5b

This species is represented by a single cast of the left valve of a typical *Gryphaea* from which the lower portion of the anterior part is missing (23025). Unfortunately, neither the exposure nor the horizon from which it came was recorded, but the partly brown-stained somewhat glauconitic chalk of which it is composed closely resembles the lowest foot of the Molecap Chalk. There is only an irregular mass of chalk where the right valve should be. Approximate original dimensions of the specimen are: height 38.5 mm, length probably about 30 mm, thickness 21 mm. Shell inequivalve. Left valve fairly large, higher than long, strongly inflated, inequilateral, slightly oblique, exterior contour in a fairly even curve, slightly more marked at the umbo. Exterior of cast smooth. Posterior half noticeably alate, with a shallow depression between the alate portion and the body of the shell; alation extending nearly to the ventral margin. Anterior half of specimen imperfect but apparently without alation. Valve apparently narrowing towards the ventral margin. Umbo prominent, directed approximately at right angles to commissure, rather short, about 4 mm in length and about 6.5 mm thick at the base, distal end rounded, slightly incurved.

Among the European Cretaceous species figured by Woods, *G. teicherti* appears to resemble most nearly *G. vesiculosa* Saw (Woods 1912, Plate LV, Figs. 10-14; Plate LVI, Figs. 1a, 1b) in general shape, but the beak of the Gingin species is much thicker, blunter and more prominent than those of Woods' specimens. In profile, *G. teicherti* is very similar in shape and convexity to a specimen of *G. vesicularis* Lam. figured by Stoliczka (1871, Plate XLIII, Figs. 1, 1a) but here also the beak of the Gingin specimen is larger and more rounded.

Gryphaea minuta, sp. nov.

Plate IV, Figs. 6, 6a, 6b

This species is represented by a single well-preserved cast of united valves from McIntyre Gully (48964), so small that were it not for the number of well-defined growth rings, one would regard it a young specimen of a larger species.

Dimensions.—Height 4.8 mm; length 4 mm; thickness 2.3 mm. The height of the right valve was probably 3.7 mm.

Description.—Shell very small, outline ovate approaching trigonal, higher than long, nearly equilateral, very inequivalve; left valve convex, right valve flat or slightly concave.

Left valve nearly semi-circular in profile, its continuity broken by several well-defined growth lamellae. Anterior margin strongly convex near the umbo and the ventral margin, nearly straight between; posterior margin rather more evenly convex; ventral margin straight in the middle, strongly convex at junction with anterior and posterior margins. Beak small, prominent, fairly sharp, slightly incurved. Exterior surface with apparently five growth ridges of which the middle three are more prominent, and are fairly high and rounded.

Right valve broadly ovate in outline; it shows faint traces of the test. The exterior surface appears to be smooth and no growth lines could be distinguished.

I have been unable to find descriptions of any other species resembling *G. minuta* at all closely.

Subgenus PYCNODONTE Fischer de Waldheim 1835

Pycnodonta ginginensis Eth. fil., 1913

Plate IV, Fig. 7; Plate V, Figs. 1-3

Pycnodonta ginginensis R. Etheridge junr. Geol. Surv. W. Aust. Bull. 55, pp. 17-19, Plate III, Figs. 6-9, Plate IV, Figs. 3-7, 1913.

Pycnodonta ginginensis was described in detail and figured by Etheridge but he made the mistake (Etheridge 1913, p. 18) of regarding the lower inflated valve as the right valve instead of the left. Although, as stated by him, the abductor impressions are sub-central, they are definitely posterior to the median line.

Apart from some species of *Inoceramus*, *P. ginginensis* is probably the commonest pelecypod in the Gingin area and it appears to be equally common in the Murchison River area, but the shells, though thick, are brittle and really well-preserved specimens are rare, few being sufficiently well-preserved for accurate measurement. With the exception of a specimen (Plate V, Figs. 1, 1a) from Toolonga Hill near the Murchison River, I have not seen any as complete as those shown by Etheridge's Plate IV, Figs. 5-7. Dimensions are given in Table VIII.

TABLE VIII

Dimensions of *Pycnodonta ginginensis*

	Left valves				Right valves	
	McIntyre Gully	48965 Molecap	Molecap	48966 Toolonga Hill	48967 Molecap	48968 McIntyre Gully
	mm.	mm.	mm.	mm.	mm.	mm.
Height	42·0?	30·7	30·0	36·0	62·5	58 ?
Length	58·0	32·0	31·5	37·5	69·0	72·5

The two right valves are the largest I have seen. Only fragments of the corresponding left valve of the McIntyre Gully specimen were recovered and this was evidently even larger than the right valve. These fragments show a very large tabular area of attachment which makes an obtuse angle of about 105° with the sides of the valve.

Description.—Shell large, thick, longer than high, oblique, inequilateral, very inequivalve, the left valve highly inflated, globose, and larger than the right, the right valve flat or concave; attached by the left valve.

Left valve variable in shape, alate, the posterior alation usually the larger and more strongly lobate, occasionally separated from the body of the valve by a deep narrow groove. Anterior alation not always noticeable and rarely lobate. Exterior surface smooth except for the widely spaced, somewhat irregular margins of thin growth laminae. In some large specimens, these are very noticeable and imbricating. Etheridge's Plate IV, Fig. 7, shows the umbo as fairly long and strongly incurved with the point close to the body of the valve; almost invariably however, the beak is truncated by a flat or concave area of attachment which may be small or may occupy a large proportion of the surface of the valve (Plate V, Fig. 3a). Owing to truncation of the umbo the ligamental area and groove are rarely present; the groove is fairly wide and shallow; the rather small area shows faint transverse striae. Interior of the valve smooth; adductor scar fairly large, shallow, semi-circular in shape and situated in the dorsal half of the valve, immediately posterior to the median line.

Right valve broadly and obliquely elliptical in outline; usually slightly concave, but some valves are very slightly convex with reverted edges (Plate V, Figs. 2, 2a); in others, the umbonal half is convex, probably corresponding to the attached area of the left valve, the remainder concave and making a considerable angle with the convex portion, a well-marked groove separating the two portions. The umbo is rarely very noticeable being, as a rule, raised only slightly above the general surface, but in some concave valves the umbonal portion takes the shape of a low dome or boss, about equal in length to half the length of the valve (Plate IV, Fig. 7a). Exterior surface usually smooth, with faint growth rings; rarely, fairly regularly spaced faint radial striae are also visible. Cardinal margin long and straight; the ligamental area varies in size, but is usually wide. In the large Molecap valve (Plate V, Figs. 2, 2a), it is about 30 mm in width, with a wide groove, but it is relatively small in the even larger McIntyre Gully specimen. Only two specimens, from Thirindine Point in the Murchison River area, are sufficiently well-preserved to show the transverse dental crenulations on each side of the ligamental area figured by Etheridge (1913, Plate IV, Fig. 3). Adductor scar large, semi-circular to nearly circular in shape, deeply incised in aged shells, and situated immediately posterior to the median line and usually just above a transverse median line.

Remarks.—At McIntyre Gully, the vertical range of *P. ginginensis* is from just above the base of the chalk to about 42 feet above. The largest specimens are usually found in the upper half of the *Marsupites* zone, the largest found by the writer being from about 18 feet above the base of the chalk. At Molecap, the largest specimens occur near the middle of the *Marsupites* zone.

The general resemblance of *P. ginginensis* to *Pycnodonta vesicularis* Lam. was noted by Etheridge (1913, p. 19), and the resemblance of specimens both from Gingin and from the Toolonga Chalk of the Murchison River area to the specimens of *P. vesicularis* figured by Woods (1912, Figs. 143-182) is so close that doubt arises as to

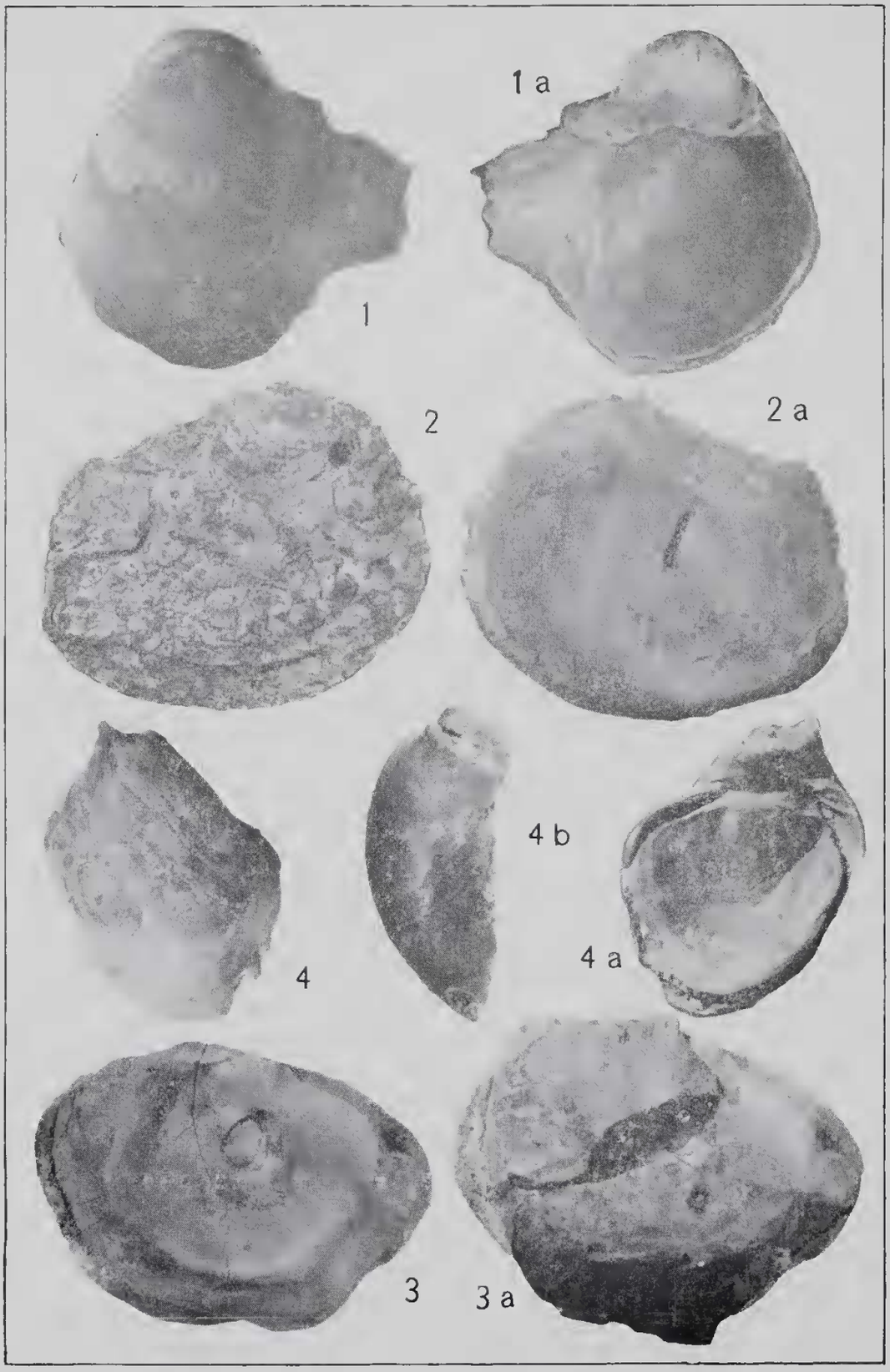

PLATE V

Pycnodonta ginginensis Eth. fil.

1.—Exterior; 1a.—Interior of hypotype, a left valve from Toolonga Hill, Murchison River area (48966), X 1¼; 2.—Exterior; 2a.—Interior of an aged right valve from Molecap (48967), X ¾; 3.—Interior of a very large right valve from McIntyre Gully; 3a.—The same, with fragments of left valve superimposed (48968), X ⅔.

Pycnodonta strathalbynensis

4.—Exterior of left valve of holotype (48969), X 2; 4a.—Exterior of right valve of holotype (48969), X 2; 4b.—Posterior profile of holotype (48969), X 2. From McIntyre Gully.

whether they do not actually belong to the one species. The radial striae characteristic of the right valves of *P. vesicularis* were visible on only two right valves from Molecap, the exterior surfaces of other right valves both from Gingin and from the Murchison River area being too eroded to show whether this feature was originally present. In Etheridge's profile (Etheridge 1913, Plate I, Fig. 7) the beak is more incurved than that of Woods' Fig. 178 (Woods 1912, p. 371) but in some small specimens from Thirindine Point in the Murchison River area, the curvature is very similar or even less than that of Woods' figure. I have not seen any right valves of which the umbo is as well developed as that of Woods' Fig. 150 (p. 367) but on the whole, the great similarity between that of *P. ginginensis* and *P. vesicularis* suggests that they belong to the same species and that any differences are those of individuals.

Pycnodonta strathalbynensis, sp. nov.

Plate V, Figs. 4, 4a, 4b, Plate VI, Fig. 1

A single fairly well-preserved small shell showing both valves, from McIntyre Gully at about 37 feet above the base of the chalk (48969), differs greatly in its proportions from typical specimens of *P. ginginensis* and appears to represent a different species. The horizon from which it comes is nearly 20 feet above that at which the largest specimens of *P. ginginensis* occur. Dimensions are given in Table IX.

TABLE IX

Dimensions of *Pycnodonta strathalbyensis*, sp. nov.

	Left valve	Right valve
	mm.	mm.
Height	21·3	14·4
Length	16·0	11·3

The thickness of the united valves is 8.6 mm.

Description.—Shell small, fairly thin, higher than long, inequilateral, obliquely ovate, very inequivalve, the left valve inflated and larger than the right, the right valve convex in the umbonal area, the remainder concave: attached by the left valve.

Left valve grypheate, fairly strongly inflated, obliquely ovate; the lateral margins somewhat compressed to form a rounded ridge extending from the umbo to the ventral margin; slightly alate posteriorly, the alate portion separated from the remainder of the valve by a shallow furrow; anterior portion of the valve slightly concave for a short distance immediately below the umbo, the remainder convex; posterior margin very slightly concave for about a quarter of the height of the valve, becoming strongly convex in the alate portion; the anterior-ventral and postero-ventral margins meet in a fairly sharp arch. Exterior surface of valve slightly rugose with fairly distinct growth rings, shaped similarly to the shape of the valve. Umbo fairly high and grypheate, but truncated in the holotype by a small, slightly concave area of attachment. Ligamental area high and fairly wide with a narrow groove directed posteriorly and set obliquely with the top immediately below the posterior edge of the truncated umbo, the anterior edge of the triangular ligamental area being much longer than the posterior. Hinge-line straight and not very long. Interior of valve smooth, the adductor scar small, shallow, nearly circular in shape and situated a little below the base of the umbonal area, posteriorly to the median line.

Right valve obliquely ovate, the umbonal portion convex, the remainder concave, a shallow groove separating the two portions in the anterior half of the valve. Anterior margin fairly evenly convex; posterior margin slightly concave immediately below the hinge-line, thence convex and bulging outwards almost to an angle opposite the alate portion of the left valve, thence nearly straight to form a rounded arch with the anterior margin at the ventral end of the valve. Umbo marginal, sharply pointed and set obliquely with its point directed towards the posterior end of the hinge: the hinge area long, flattened and bent slightly forward in the middle, the ligamental area occupying the flattened portion. Exterior of valve smooth except for a few faint narrow growth rings round the umbo. Interior surface smooth except for a few low growth ridges in the middle third, adductor scar large and ovate in shape, situated immediately posterior to the median line and occupying a large part of the ventral half of the concave portion which corresponds to the convex umbonal portion of the exterior. The concave area extends ventrally for nearly half the height of the valve, being deepest immediately below the hinge.

Remarks.—The principal difference between this species and *P. ginginensis* is in the proportions of height to length. In both valves of *P. ginginensis* the length is almost invariably greater, sometimes much greater, than the height, whereas in *P. strathalbynensis* the height of the left valve is much greater, that of the right valve very slightly greater, than the length.

P. strathalbynensis shows a very close resemblance to *Gryphaea vesiculosa* Sow. from the Upper Greensand of Warminster, England (Woods 1912, pp. 374, 375; Plate LV, Figs. 10-14. Plate LVI, Fig. 1). Indeed Woods' description of that species might very well fit the Gingin shell. So far as can be judged from the single specimen, *P. strathalbynensis* is rather more oblique than *G. vesiculosa*, the ligamental area of its left valve being particularly so and a median line from the apex of the ligamental groove to the middle of the ventral margin would show a much greater curve than those of the specimens of *G. vesiculosa* figured by Woods, which show the ligamental area of the left valve to be directly below the umbo, whereas in the Gingin specimen it is situated posteriorly to the umbo, which is evidently grypheate, but owing to truncation of the holotype its exact shape is unknown.

Genus EXOGYRA Say, 1820

Exogyra variabilis, sp. nov.

Plate VI, Figs. 2-10

Specimens of *Exogyra* are fairly common in the Gingin area, especially at McIntyre Gully, where their vertical range is from the base of the chalk to possibly 40 feet above. They are also fairly common at Molecap.

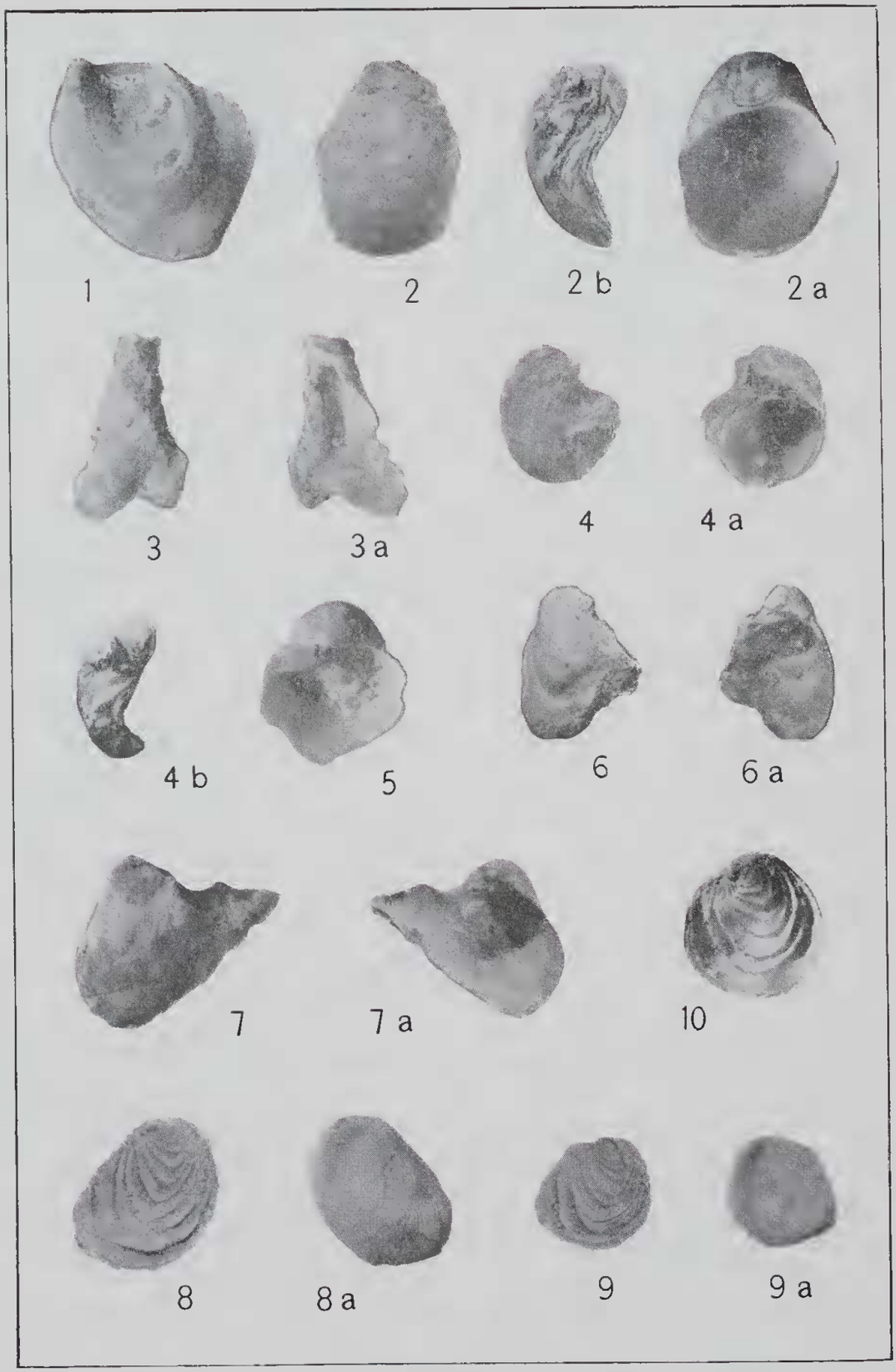

PLATE VI

Pycnodonta strathalbynensis

1.—Interior of right valve of holotype (48969), X 2.

Exogyra variabilis

2.—Exterior; 2a.—Interior; 2b.—Posterior profile of holotype (48970), a left valve from McIntyre Gully, X 2; 3.—Exterior; 3a.—Interior of left valve, variation A (48971), from McIntyre Gully, X 2; 4.—Exterior; 4a.—Interior; 4b.—Posterior profile of left valve, variation B (48972), from Molecap, X 2; 5.—Interior of left valve, variation C (48973), from McIntyre Gully, X 2; 6.—Exterior; 6a.—Interior of left valve between variations B and D (48974), from McIntyre Gully, X 2; 7.—Exterior; 7a.—Interior of left valve of variation D (48975), from McIntyre Gully, X 2; 8.—Exterior; 8a.—Interior of a typical right valve (48976), from Molecap, X 2; 9.—Exterior; 9a.—Interior of another right valve (48977), from Molecap, X 2; 10.—Exterior of a more nearly circular right valve (48978), locality not stated, X 2.

Individual left valves vary so greatly in shape that at first sight one is inclined to regard them as representing more than one species. A careful analysis of 34 fairly well-preserved specimens however, showed every gradation between the extreme forms and all would appear to be merely variations of the one species. The different variations do not appear to be characteristic of any particular horizon and two very different forms may come from approximately the same horizon.

The principal variations are as follows:—

The type. A nearly elliptical and nearly equilateral form, non-alate or with only a trace of posterior alation. Approximately half the specimens are of this type, from which the other forms probably originated, and a well-preserved specimen from McIntyre Gully has been chosen as the holotype of the species.

A. A high trigonal non-alate form, widest near the ventral margin, with high beak which is twisted, rather than curved, posteriorly.

B. A broad, very inequilateral form with broad and deep rounded posterior alation only.

C. A broadly ovate, more nearly equilateral form with nearly equal rounded posterior and anterior alation.

D. A very inequilateral more oblique form with high, very elongate, and sharply pointed posterior alation.

Two small valves without posterior alation show narrow anterior alation.

Only six specimens show definite areas of attachment, the position depending on the form of the valve. One large imperfect specimen is almost wholly attached.

The right valves of the species are operculiform and are all very similar to each other whatever the form of the corresponding left valve. Dimensions are given in Table X.

TABLE X

Dimensions of *Exogyra variabilis*, sp. nov.

	Left valves					Right valves		
	Holotype 48970 McIntyre Gully	Variant A 48971 McIntyre Gully	Variant B 48972 Molecap	Variant C 48973 McIntyre Gully	Variant D 48975 McIntyre Gully	All from Molecap		
	mm.	mm.	mm.	mm.	mm.	mm.		
Height	12·7	12·5	9·4	9·8	10·8	9·4	11·0	7·8
Length	9·7	7·5	7·9	9·5	13·7	9·0	8·0	7·2

Description.—Shell small, thin, ovate, height greater than length, usually slightly oblique and inequilateral, very inequivalve, the left valve highly inflated, non-alate to alate, and larger than the right which is operculiform and usually concave. The beaks of both valves are curved posteriorly, that of the left valve being moderately large, that of the right valve very small. The type (Plate VI, Figs, 2, 2a, 2b).—Left valve highly inflated, fairly evenly convex in profile, ovate, with the widest portion opposite the middle of the valve, higher than long, the length equal to approximately three-quarters the height, nearly equilateral, non-alate; margins fairly evenly convex, the anterior and posterior merging into the ventral. Umbonal portion large and shaped like a hood above the remainder of the valve, with the hinge-line situated at about one-third the height of the valve below the top of the umbo. The hinge-line forming an even concave curve with the highest point anterior to the median line. The beak itself is long and broad, but not very prominent; it extends from the top of the valve almost to the hinge-line, and is curved posteriorly. Except for faint growth ridges the exterior surface is fairly smooth, except near the posterior margin. Interior surface smooth. Adductor scar of moderate size, elliptical and situated high up in the posterior half of the valve, being nearly hidden by the umbonal hood.

Right valve operculiform, concave, obliquely ovate to nearly circular in outline; height greater than length, inequilateral; anterior margin with an even convex curve and merging into the ventral; posterior margin nearly straight to strongly convex in the nearly circular specimens. Beak exceedingly small, curved posteriorly. Exterior surface decorated usually with about 7 to 9 fairly evenly spaced strongly imbricating growth-rings, each ending in an arch directed ventrally. A line joining the points of the arches would show a fairly marked curve, convex anteriorly. Interior of valve smooth except for the fairly large, shallow ovate adductor scar situated about half-way between the median line and the posterior margin and with its centre on or slightly above a median transverse line. On the average the height of a right valve is about three-fifths that of the corresponding left valve.

Variation A (Plate VI, Figs. 3, 3a).—Left valve moderately inflated, height much greater than length, sub-trigonal in outline, approaching a scalene triangle with the most acute angle at the umbo, an interior margin being the longest; anterior margin of specimen imperfect but apparently nearly straight; posterior margin slightly concave and considerably shorter than the anterior; ventral margin fairly evenly convex but imperfect in the specimen figured. The valve widest at a little more than three-quarters the height of the valve below the umbo. The umbo twisted rather than curved posteriorly; top of umbo of the specimen flattened by a small concave area of attachment. Hinge-line fairly sharply angular. Exterior surface somewhat rugose, with narrowly-spaced growth-ridges on the umbonal half; interior surface smooth. The specimen is from the *Ostrea philbeyi* zone of McIntyre Gully at about 22 feet above the base of the chalk.

Variation B (Plate VI, Figs. 4, 4a, 4b).—With posterior alation only. Left valve strongly inflated, height somewhat greater than length, slightly oblique, very inequilateral; markedly alate posteriorly, the alation both wide and deep, with the widest portion about opposite the middle of the valve. The posterior portion of the valve is concave between the umbo and the alation, but the remainder of the valve is strongly convex; the margins are all convexly curved; the hinge-line showing a fairly even

curve and merging into the anterior and posterior margins which, in turn, merge into the ventral. The umbonal portion of the valve extends in depth to nearly two-fifths of the height of the valve, the beak itself is large, rather thick and shows a marked posterior curve. Exterior surface of the body of the valve slightly rugose, with rather faint growth-lamellae, the alate portion strongly rugose; interior of valve smooth; adductor scar fairly large, ovate, hidden by the umbonal hood. The specimen figured is from Molecap.

Variation C (Plate VI, Fig. 5).—The bi-alate form. Left valve fairly strongly inflated, height only slightly greater than length, nearly equilateral in outline. Hooded umbonal portion wide and fairly deep; the beak large, curved posteriorly; hinge-line of specimen somewhat irregular, thickest and with a convex curve at the top of the posterior wing; margins below the hinge-line fairly evenly rounded. Posterior alation usually larger than the anterior, but in one small specimen, the two are approximately equal; the alations are usually moderately wide and deep and merge into the ventral margin. The widest portion of the valve is at about three-fifths of the height of the valve below the top of the umbo. The position of the area of attachment of this form and of variation B is usually at the base of the umbo. The specimen figured is from McIntyre Gully, but from what height above the base of the chalk was not recorded.

Variation D (Plate VI, Figs. 7, 7a).—The high-winged form. Left valve fairly strongly inflated, very inequilateral. Excluding the wing, the valve is obliquely ovate, the length about equal to three-quarters the height; with the wing, the length is much greater in well-developed specimens, but in some the wing is quite narrow; in the specimen figured, the length of the wing is equal to more than half the height of the valve. The wing is not sharply marked off from the body of the valve; the widest portion is in continuation with the hinge-line and about opposite the base of the umbo from which it is separated by a fairly wide furrow; the dorsal margin is nearly straight and ends in a sharp point from which the posterior margin descends, usually in a straight line, to the ventral margin; anterior margin of the valve convexly curved, the convexity being greater in the ventral half. Hinge-line slightly curved. Umbo usually not so deep, proportionally, as in the other forms and the beak itself is relatively slightly smaller. Exterior of valve fairly smooth except for rather faint growth-rings, the alate portion being rather more rugose. Interior of valve smooth; the adductor scar situated very high up and hidden by the umbo. The area of attachment is in the furrow between the base of the umbo and the wing.

This form apparently merges into the broad mid-wing form of variation B. The specimen figured is from the *Ostrea philbeyi* zone of McIntyre Gully at about 22 feet above the base of chalk.

Remarks.—*Exogyra variabilis* shows some resemblance to the European *E. canaliculata* Sow. (Woods 1912, pp. 375-379, plate LVI, Figs. 2-16), the more alate specimens figured by Woods in particular resembling less markedly developed specimens of Variation D. Woods' Fig. 6 is somewhat like the non-alate form of *E. variabilis* but is narrower and more sharply ovate. The right valves of the two species are very similar.

Apart from the direction of curvature of the beak, *E. variabilis* resembles fairly closely shells of the sub-genus *Gryphostrea* Conrad, in which, however, the beak is always curved anteriorly; the non-alate form much resembling a specimen of *G. inscripta* d'Arch. figured by Cossman (1922, Plate XIII, Figs. 8, 9, 21) and specimens of Variation C are not unlike *G. boussaci* Doncieux which Cossman (1922, p. 211, Plate XIII, Figs. 28, 29) regarded as an alate variety of *G. inscripta*.

Authors differ as to the relationships of the subgenus *Gryphostrea* which appears to have taken the place of *Exogyra* in Eocene times. It first appeared in Upper Cretaceous times as *G. vomer* Morton, considered to be identical with the Eocene *G. eversa* Deshayes, chosen as the type species by Conrad. Stoliczka (1871) placed *Gryphostrea* under *Gryphea*, but Mayer (1875) and some later authors regarded *G. eversa* as an *Exogyra* (see Cossman 1922, p. 210). Woods who recognised only *Ostrea* and *Exogyra* as genera, considered (1912, pp. 378, 379) that *Gryphostrea canaliculata* was probably related to *Pycnodonta vesicularis*. Gardner (1916, p. 579) stated: "*Gyphostrea* suggests *Exogyra* in the gyrate umbones of the left valve. The beak of the right valve of the former, however, is orthogyrate or at the most slightly inclined, and this, together with the inflation of the beak of the left valve, allies it more closely with *Gryphaea* than with *Exogyra*." Gardner's remarks could be applied equally well to *Exogyra* of the *E. variabilis* group. Cossman (1922) placed *Gryphostrea* together with *Pycnodonta* under the genus *Liostrea* Douville, of which *Ostrea sublamellosa* is the type species. Shimer and Schrock (1944) gave generic rank to *Gryphaea*, but placed *Gryphostrea* under *Ostrea*.

The only important difference between *Exogyra* and *Gryphostrea* is in the direction of curvature of the beak, which in *Exogyra* is curved posteriorly in *Gryphostrea* anteriorly. Other differences are of no greater than specific value, and the difference in the direction of curvature may be only one of a few degrees; as, for example, between the holotype of *Exogyra variabilis* (Plate VI, Fig. 2a) and the specimen of *Gryphostrea inscripta* figured by Cossman (1922, Plate XIII, Fig. 8), and it seems most probable that *Gryphostrea* was originally derived from species of *Exogyra* and should be regarded as a subgenus of that genus.

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